Dolia K., Dolia O.

International Science Group
ISG-KONF.COM

MODELING TRANSPORT PROCESSES WITH GEOINFORMATIVE TECHNOLOGIES

ISBN 979-8-88722-628-6
DOI 10.46299/979-8-88722-628-6

Dolia K., Dolia O.

MODELING TRANSPORT PROCESSES WITH GEOINFORMATIVE TECHNOLOGIES

Monograph

2022

UDC 004.94:656

Author's:

Dolia K., Doctor of engineering sciences, Department of automobile and transport infrastructure, National Aerospace University “Kharkiv Aviation Institute”;

Dolia O., Candidate of Technical Sciences, Associate Professor Department of Information Control Systems, Kharkiv National University Of Radio Electronics

Editor:

Shibaev O., Doctor of engineering sciences on specialty ‘Transport Systems’,prof. of 'Fleet Operation and Sea Transportation Technologies' Dpt., Educational and Scientific Institute of Marine Business, Odesa National Maritime University;

Koskina Y., Doctor of engineering sciences on specialty ‘Transport Systems’, prof. of 'Fleet Operation and Sea Transportation Technologies' Dpt., Educational and Scientific Institute of Marine Business, Odesa National Maritime University

Dolia K., Dolia O. (2022). Modeling transport processes with geoinformative technologies [monograph]. Primedia eLaunch. https://doi.org/10.46299/979-8-88722-628-6

ISBN – 979-8-88722-628-6
DOI – 10.46299/979-8-88722-628-6

The monograph presents new conceptual approaches to solving transport issues, which are implemented with the help of network analysis tools. The latest information systems for determining the basic characteristics and formalizing the parameters of transport processes are used.

A wide range of topical problems of transport industry is considered. Examples of solving the main problems of transport technologies are given. Approaches to the use of geoinformation technologies for modeling and analyzing the processes of transport systems are proposed.

UDC 004.94:656

ISBN – 979-8-88722-628-6

CONTENT

INTRODUCTION

Each type of transport is evaluated according to separate criteria and indicators of performance evaluation, which reflect different aspects of the organization of the transport process. At the same time, a number of common indicators can be identified that characterize the advantages and features of a particular mode of transport.

Planning the work of the transport industry is to compile an annual (quarterly) plan of production and economic activities to break down the main indicators by month. This plan provides for the calculation of the production program (transportation plan), the volume of loading and unloading, the number of vehicles and machinery, the number of workers, wages, cost estimates and other indicators of transport.

Analysis of the existing methods of planning the volume of traffic on road transport shows that most of the calculation methods are used, which do not provide a scientific basis for plans for the transportation of goods.

To increase the scientific validity of cargo transportation plans are traditional methods planning worth it to supplement more wide range of economic and mathematical methods and forecasting methods.

To date, more than 130 different methods, techniques and typical models are known, which are used or proposed for use in forecasting.

In terms of the interdependence of past and future, there are two types of forecasts - research and intuitive. Research predictions are developed after studying systematic information about the state, behavior, and causes of changes in the predicted process and are based on rigorous mathematical methods that take into account the inertia of the process, while intuitive predictions usually have a large "horizon" for forecasting. becomes scientific or practical intuition.

Nowadays, the following basic methods are distinguished: qualitative analysis, extrapolation, expert evaluations and modeling.

The developed classification of forecasting methods allows to choose a certain method for forecasting the volume of traffic and other performance indicators of motor transport enterprises based on the analysis of the dynamics of the economic situation

for the previous period. Forecasting the volume of traffic is based on the results of the analysis of the past, therefore, describes the perspective to the extent that it is determined by objectively stable phenomena and processes. In addition, the main methods and models of extrapolation are used.

There are several classes of software that differ in their functionality and technological stages of processing geographic information.

Software software are distributed on five the main classes used.

The first, functionally most complete class of software is instrumental GIS. They can be designed for a variety of tasks: to organize the input of information (both cartographic and attributive), its storage, testing complex information requests, solving spatial analytical problems (corridors, environments, network tasks, etc.), construction of derivative maps and schemes operations) and for preparation of the conclusion on a firm carrier of original models of cartographic and schematic production. Typically, GIS tools support work with both raster and vector images, have a built-in database for digital basis and attribute information, or support for storing attribute information one of the common databases - Paradox, Access, Oracle and others.

The second important class is the so-called GIS viewers, ie software products that provide the use of databases created using instrumental GIS. Typically, GIS viewers provide the user (if any) with extremely limited opportunities to replenish databases. All GIS viewers include tools for querying databases that perform positioning and scaling operations on cartographic images. Viewers are always part of medium and large projects, reducing the cost of creating a certain part of jobs that are not provided with the rights to replenish databases.

ESRI's ArcGIS software line stands out among other GIS packages with advanced modeling tools based on geodata and spatial analysis. This line is used to comprehensively solve large-scale problems of the transport industry.

Intermodal freight transport is receiving increased attention as congestion, environmental and traffic safety issues remain unresolved. The strategic importance of speed and ingenuity in securing the supply chain forces firms to reconsider traditional

logistics services. As a result, researchers are growing interested in the problems of intermodal freight transport.

The success of many companies depends on the use of transport networks that move goods and cargo. GIS is used to solve the problem of transportation, which is reduced to finding (finding) the optimal route of transportation by the existing transport architecture of the region. The road network can be represented as a high-level spatial geometric object, and the task of finding the optimal route is to search on the graph of interconnected sections of the network that meet the specified initial conditions. All information that affects the selection of links of the route, namely: the attributes of cargo, vehicle, transport infrastructure - must also be taken into account. This combination of the use of spatial and attributive data is the scope of geographic information systems.

The purpose of the geographic information system of freight is to improve the quality of road freight, the efficiency of decisions, the "validity" of the existing routes of freight, reducing the number of errors of a subjective nature.

For each object on the map you can get detailed reference information. It is enough to point the mouse to the object of interest - and in the pop-up dialog will appear information not only about him but also about other objects within it.

Thus, in the case of setting different transport parameters, GIS is able to build several alternative route options, which can be further evaluated in terms of cost and on the basis of the obtained data to decide on the final route.

In the process of working with the geographic information system, the end user accumulates data on successfully constructed routes and the initial conditions for the construction of these routes in the knowledge base for further reuse of this information under similar conditions.

In terms of architecture, the most popular and competitive option for developing a geographic information system is a geographic information service that allows users to work through an Internet browser from personal computers and is an application for mobile devices.

1 CREATION OF NETWORK DATA SETS AND THEIR ANALYSIS

1.1 Creating a network data set

Network data sets are used to model engineering networks, including transport ones. They are created from initial objects, which can consist of simple objects (lines and points) and turns, as well as maintain the connectivity of the original objects. All types of analysis with the simultaneous use of the optional module ArcGIS Network Analyst extension are performed using a set of network data.

The network data set simulates the street network shown in Figure 1.1. The figure shows that one-way streets, turn restrictions and overpasses / tunnels can be simulated. Network analysis operations, such as point-to-point route search, are performed based on the properties of the network data set. To understand the meaning and importance of the concept of connectivity, it should be borne in mind that objects usually do not contain information about the existence of each other. For example, if two linear objects intersect, neither line contains information about them. Similarly, a point object at the end of a linear object does not contain specific information about that line, but the network data set contains information about which initial objects match. The network data set is characterized by connectivity that can be changed to determine which of the matching objects are really connected. As a result, it is possible to model tunnels and overpasses in the absence of communication between roads. Thus, when performing network analysis, the calculation mechanisms contain information about which simulation tools can be applied to a particular network.

To create a set of network data in the geodatabase, you must use the objects "Turns" and "Streets" (Kharkov). You also need to include traffic history data to calculate time-bound routes.

Determine the sequence of operations to create network data from geographic information about the city of Kharkiv. To do this, use ArcGIS software and ESRY's ArcCatalog module.

The software selected for operation is provided by ESRY for use in the educational process.

Let's define kinds of technological works and their order concerning geoinformation data for creation of a set of network data.

1. Activate the optional ArcGIS Network Analyst module by running the following actions:

a) click on Settings(Customize)> Additional modules (Extensions); the Extensions dialog box opens.

b) mark ArcGIS Network Analyst;

c) click Close;

2. On the Standard toolbar, click Connect To Folder.

The Connect to Folder dialog box opens.

3. Go to the folder with updated geo-information materials about the city of Kharkiv with materials from the Network Analyst module.

The shortcut for this folder will be added to the Catalog Tree under the Folders Connection heading.

4. In the Catalog Tree, expand the node ... \…> Kharkiv.gdb.

5. Click on the Transportation feature set.

The feature classes contained in the feature class set are listed on the Contents tab in ArcCatalog.

6. Right-click the Transportation and New> Network Dataset feature sets.

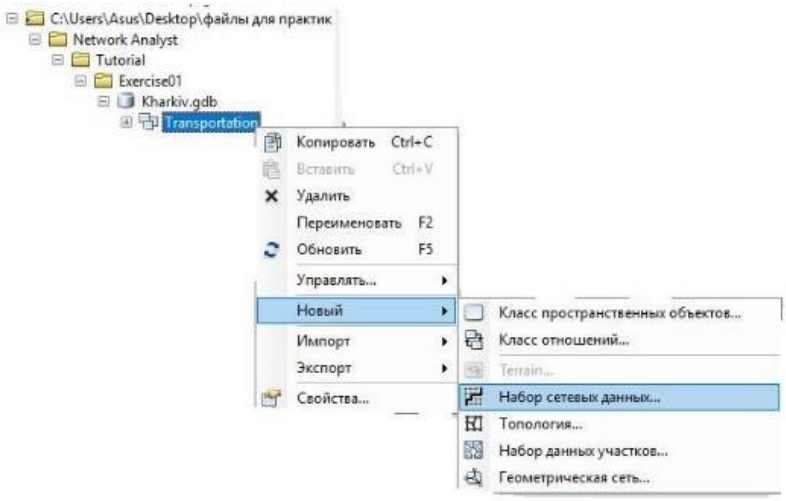


Figure 1.1

The New Network Dataset wizard opens.

Note. To open the New Network Dataset wizard in the geodatabase, right-click the feature class set that contains the source feature classes (such as streets) and choose New (New)> Network Dataset). To create a network data set using a shapefile, right-click the Street shapefile itself (not the workspace that contains the shapefile) and choose New> Network Dataset.

The reason for the difference is that geodatabase networks allow the use of different sources stored in a feature class set to create a multimodal network, while shapefile network datasets can handle only one source feature class.

7. Enter Streets_ND as the name of the network data set (Figure 1.2).

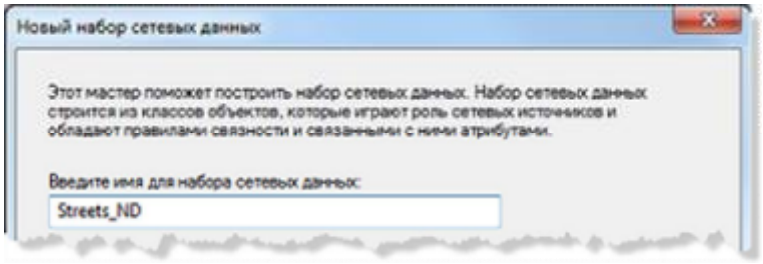


Figure 1.2

The Select a version for your network dataset option must be set to the latest version.

This option is convenient for hosting a set of network data for access by users using earlier versions of ArcGIS. They will be able to open a network dataset created and shared for public if a version number less than or equal to their ArcGIS version number is selected. The disadvantage of this choice is that the new network data set cannot include the functionality that appeared in the new versions of ArcGIS - the controls for adding these functions in the New Network Dataset wizard will be inactive. If you do not need to share the network data set, or if the users who will have access to it have the same versions of ArcGIS, it would be wise to choose the latest version.

8. Click Next.

9. Installparameter class objects Streets, to use it as a source for a network data set.

10. Click Next.

11. Click Yes to simulate network turns.

12. Check Restricted Turns to use this source of rotation objects. The 'Global Turns' option must already be checked. By default, it allows you to add default penalties for turns (Fig. 1.3).

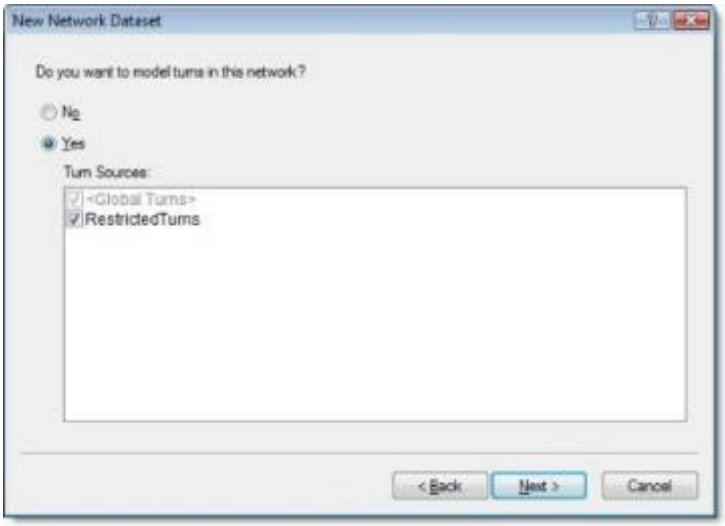


Figure 1.3

13. Click Next.

14. Click Connectivity.

The Connectivity dialog box opens. Here you can set the network connectivity model.

For a certain class of "Streets" objects, streets are connected to each other at end points.

15. Make sure Streets is set to End Point.

16. Click OK to return to the New Network Dataset wizard.

17. Click Next.

18. This dataset has altitude fields, so make sure that the Use Elevation Fields option is selected.

Relief settings in the network data set further determine network connectivity. Let's show it by an example. Suppose that two edges have endpoints that coincide in coordinates X, Y, but their heights are different: one endpoint is located above the other. In addition, assume that the connectivity function is set for Endpoints. If the

heights of the points do not matter, the edges are connected. On the other hand, if the heights are taken into account, they will not connect.

There are two ways to model the terrain: using the true values of the heights of geometry or using logical values of heights in the fields of heights.

The Street object class has logical elevation values stored as integers in the ID fields. If, for example, two coincident endpoints have a field height value of 1, then the edges are connected. However, if one of the endpoints is 1 and the other matching point is 0 (zero), the edges do not connect (match). Network Analyst recognizes field names in this dataset and automatically assigns them to the map, as shown in Figure 1.4 (The height field function can only be performed with integer fields).

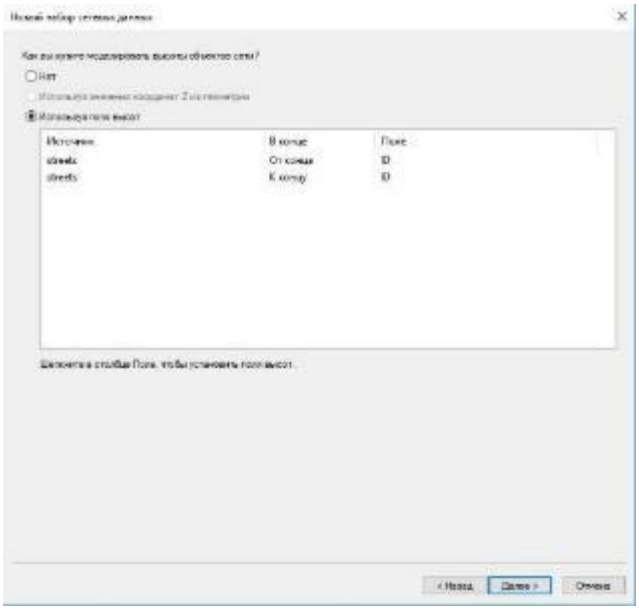


Figure 1.4

19. Click Next.

The page for configuring network attributes will look like this (Fig. 1.5).

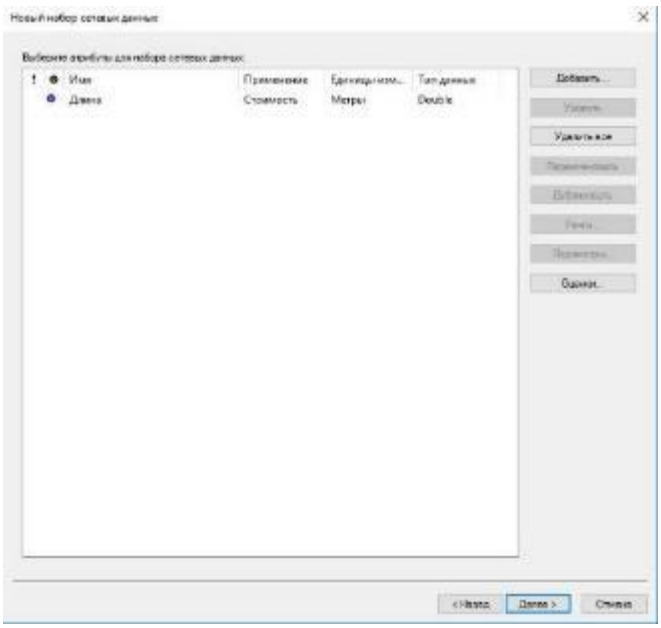


Figure 1.5

Network attributes are network properties that describe navigation in a network. Typical examples are cost attributes that act as impedances in a network and restriction attributes that prohibit passage in both or one direction (for example, if roads are one-way).

Network Analyst analyzes the source classes of spatial objects for standard fields, such as Meters, Minutes (FT_Minutes, and TF_Minutes, depending on the direction) or One way. If such fields are detected, the corresponding network attributes associated with these fields will be automatically created (the results of this process can be seen by clicking on Evaluators).

You need to add some network attributes yourself.

20. Click Add.

The Add New Attribute dialog box opens

21. Enter Meters in the Name field.
22. For Usage Type, select Cost.
23. For Units, select Meters.
24. Leave the Data Type Double (Fig. 1.6).

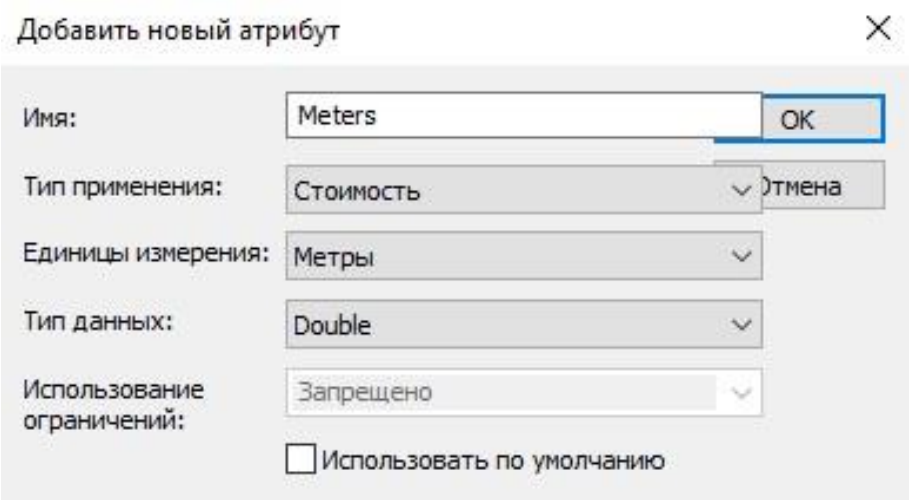


Figure 1.6

25. Click OK (Figure 1.7).

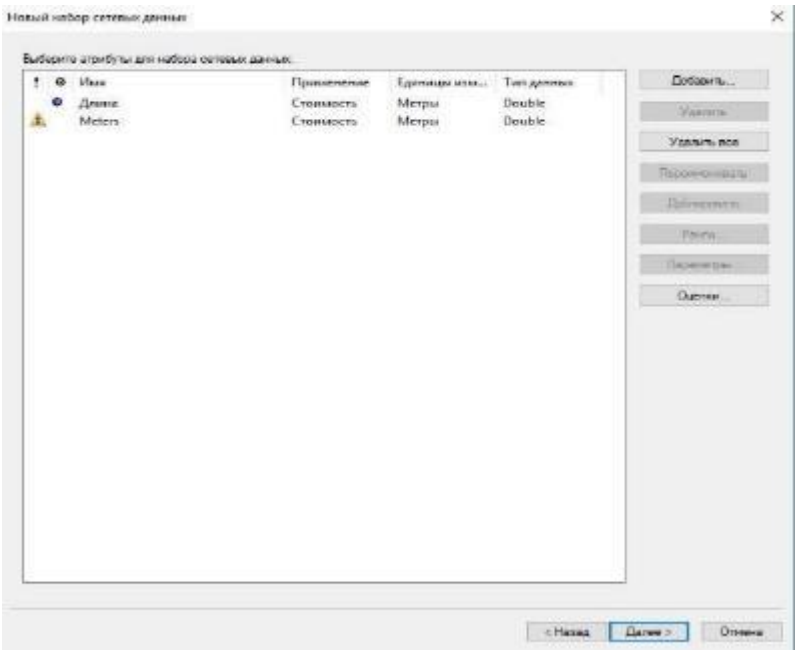


Figure 1.7

26. Click the Meters bar to select, then click Evaluators to set how the network attribute values are defined.

The Evaluators dialog box opens.

27. Next, you need to click on the Type column and select Field, then on the Value column and select LENGTH (Fig. 1.8).

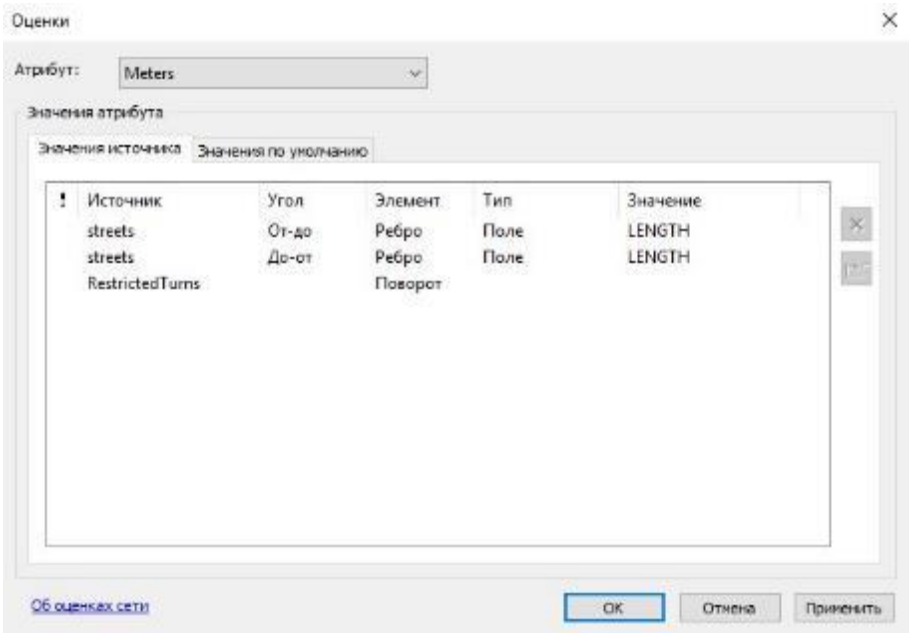


Figure 1.8

28. Click OK.
29. Click Add.

It will open dialogwindow Addition new attribute.

30. Enter Minutes in the Name field.
31. For Usage Type, select Cost

(Cost).

32. For Units, select Minutes
33. Leave the Data type Double (Fig. 1.9).

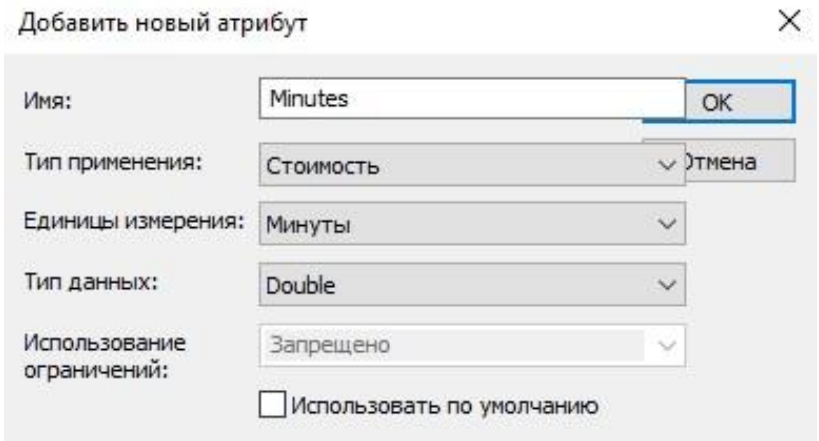


Figure 1.9

34. Click OK.

35. Click the Minutes bar to select, then click Evaluators to see how the network attribute values are defined.

The Evaluators dialog box opens.

36. Next, click on the Type column and select

Field, then the Value column and select LENGTH (Fig. 1.10).

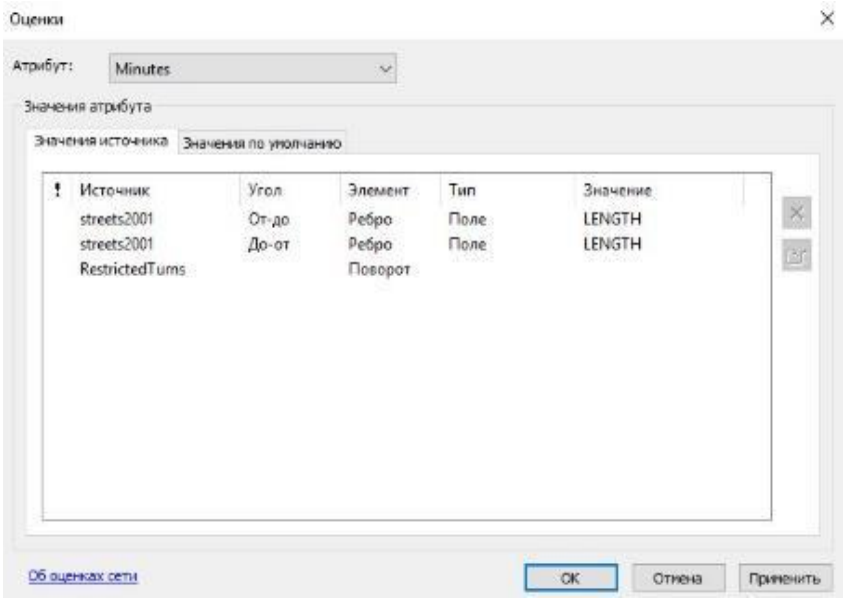


Figure 1.10

37. Next you need to go to the Default Value, in the Elements Rotate mark Type instead of Constant - Allow global turns (Fig. 1.11).

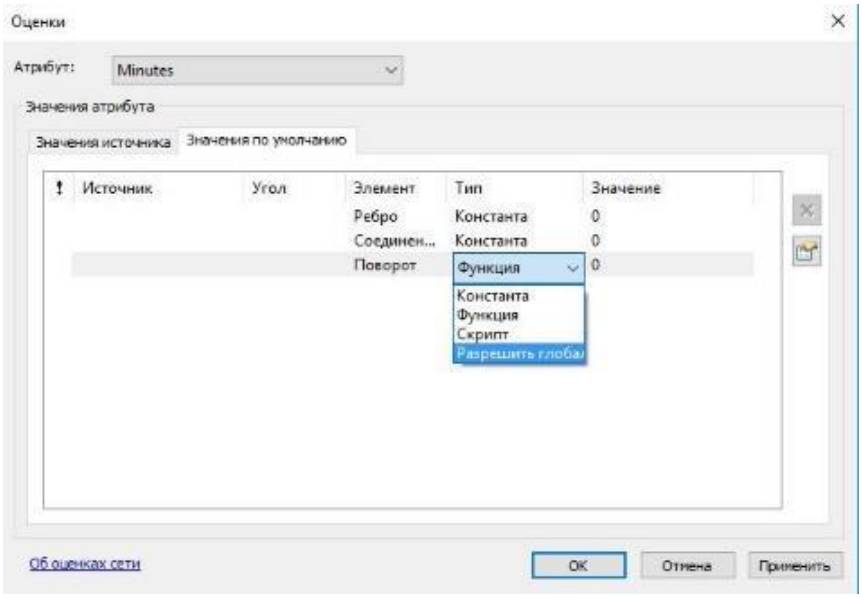


Figure 1.11

38. Click Apply, and then click OK.

39. Click Add.

The Add New Attribute dialog box opens.

Enter One way in the Name field.

40. For Usage Type, select Restriction.

41. Leave the Data Type Prohibited (Fig. 1.12).

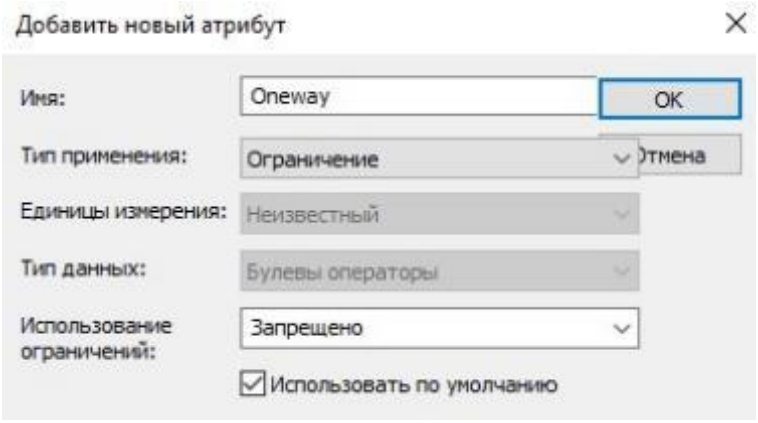


Figure 1.12

42. Click OK.

43. Click Add.

It will open dialogwindow Addition new attribute.

44. Enter Road Class in the Name field.

45. For Usage Type, select Descriptor.

46. For Units, select Uknown.

47. Select Data type Integer (Fig. 1.13).

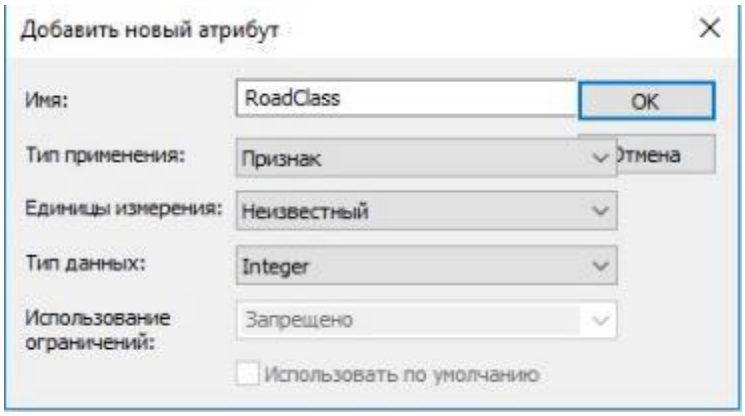


Figure 1.13

48. Click OK.

49. Click Add.

50. The Add New Attribute dialog box opens.

51. Enter Travel Time in the Name field

52. For Usage Type, select Cost.

53. For Units, select Minutes.

54. Leave Data type Double, check Use default (Fig. 1.14).

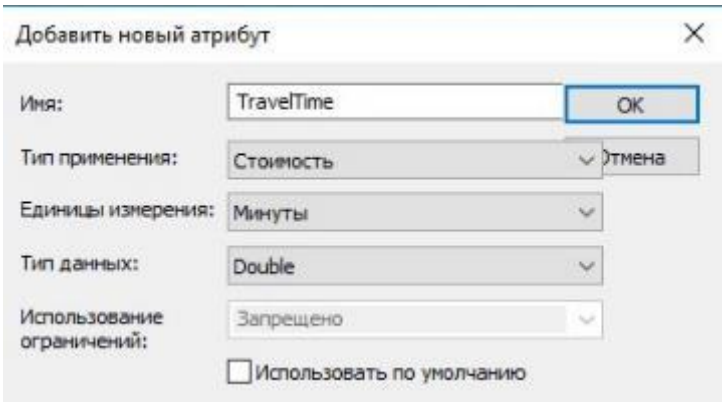


Figure 1.14

55. Click OK.

56. Click Travel Time to select, then click Evaluators to set how network attribute values are defined.

57. The Evaluators dialog box opens.

58. Next you need to click on the Type column and select Field, then on the Value column and select LENGTH (Fig. 1.15).

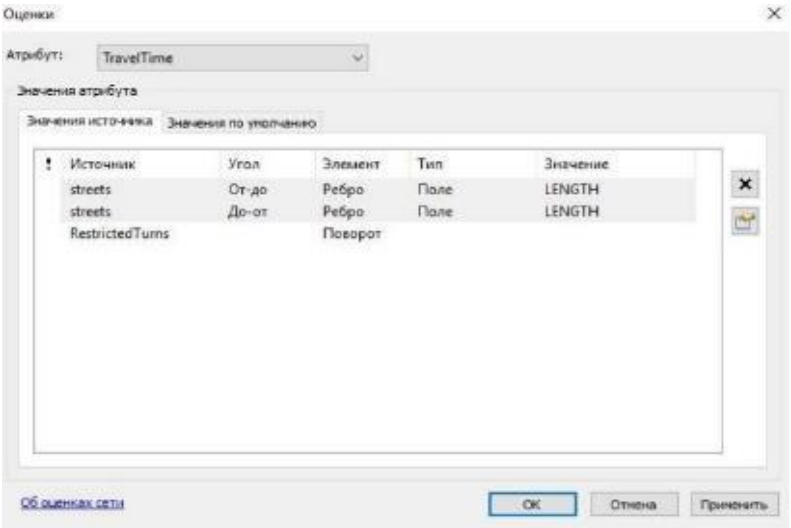


Figure 1.15

59. Next you need to go to the Default Value (Default Value), in the Elements (Elements) Rotate mark Type instead of Constant - Allow global turns (Allow global turns) (Fig. 1.16).

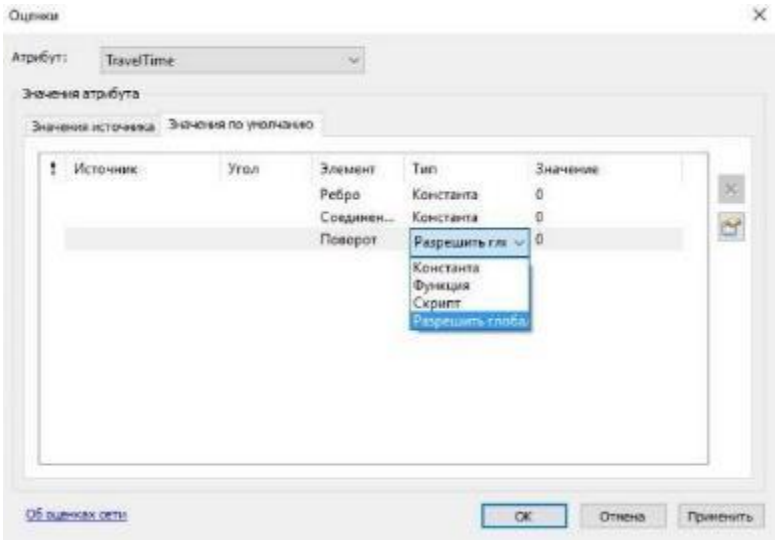


Figure 1.16

60. Click Apply, and then click OK.

61. Click Add.

The Add New Attribute dialog box opens.

62. Enter Weekday Fallback Travel Time in the Name field.

63. For Usage Type, select Cost.

64. For Units, select Minutes.

65. Leave the Data type Double, check Use default (Fig. 1.17).

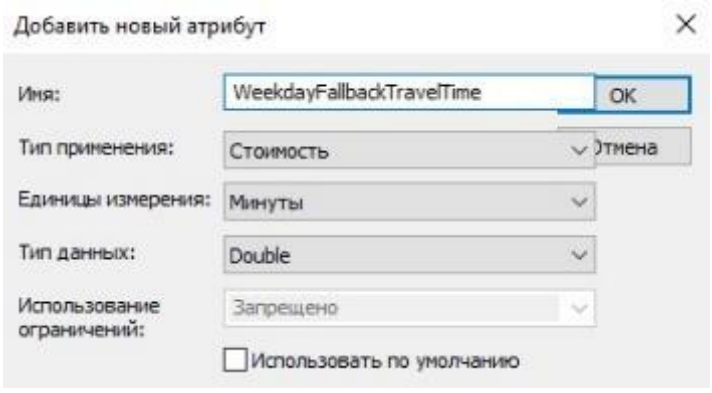


Figure 1.17

66. Click OK.

67. Click the Weekday Fallback Travel Time bar to select, then click Evaluators to set how network attribute values are defined.

68. The Evaluators dialog box opens.

69. Next you need to click on the Type column and select Field, then on the Value column and select LENGTH (Fig. 1.18).

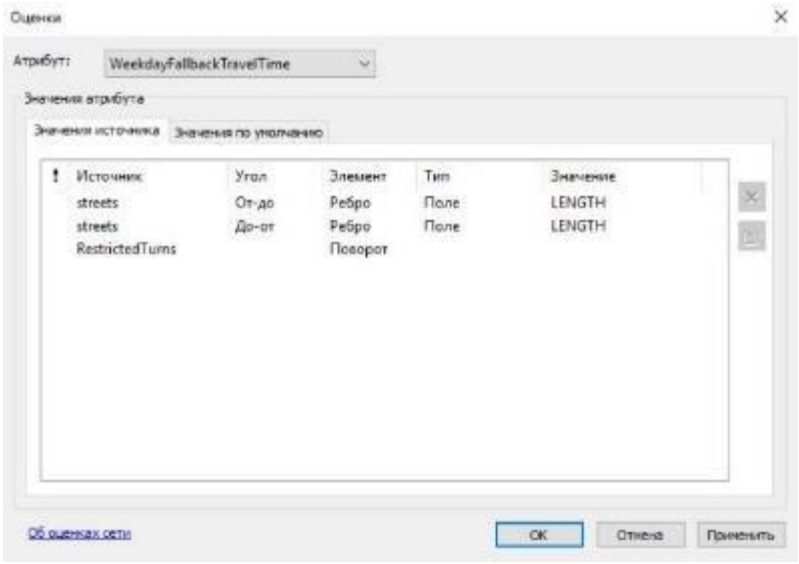


Figure 1.18

70. Further necessary to go to (Default Value), in Elements, select Type instead of Constant - Allow global turns (Fig. 1.19).

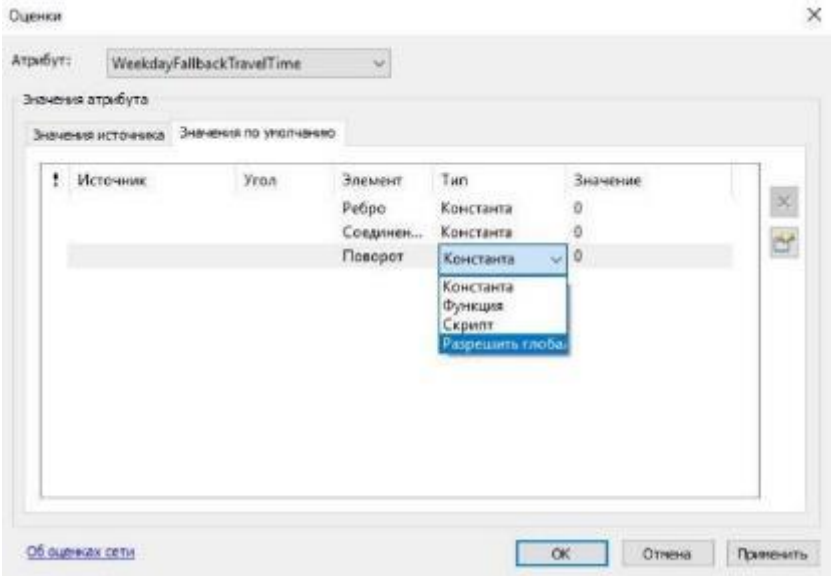


Figure 1.19

71. Click Apply and click OK.

72. Click Add.

The Add New Attribute dialog box opens

73. Enter WeekendFallbackTravelTime in the Name field.

74. Select the value for Usage Type Cost (Fig. 1.20).

75. For Units, select Minutes.

76. Leave the Data type Double, check the Use default (Fig. 1.20).

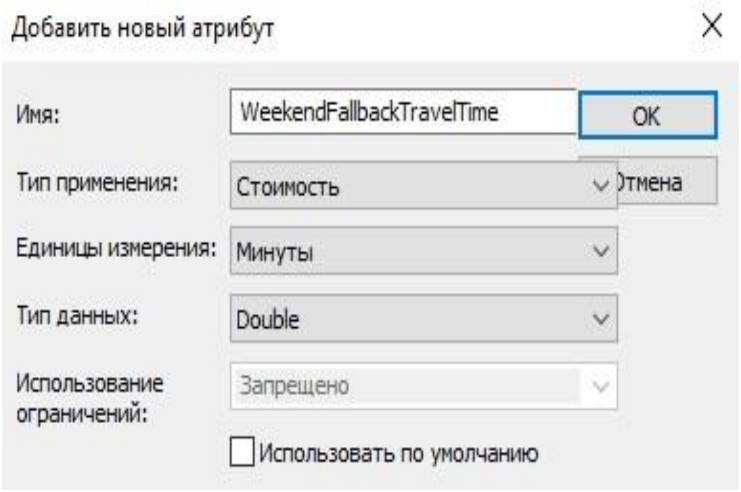


Figure 1.20

77. Click OK.

78. Click the Weekend Fallback Travel Time bar to select, and then click Evaluators to set how network attribute values are defined.

The Evaluators dialog box opens.

79. Next you need to click on the Type column and select Field, then on the Value column and select LENGTH (Fig. 1.21).

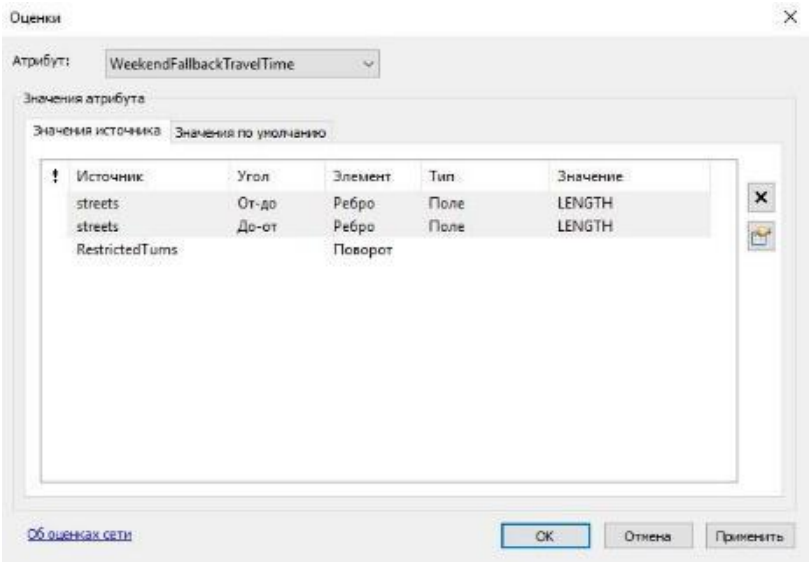


Figure 1.21

80. Next, you need to go to the Default Value (Default Value), in the Elements (Elements) Rotate mark Type instead of Constant - Allow global turns (Allow global turns) (Fig. 1.22).

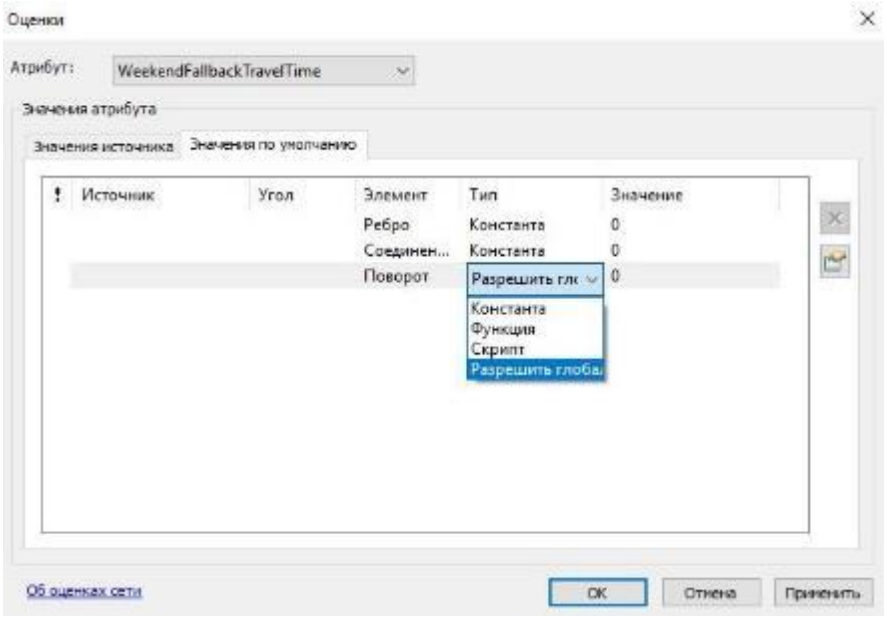


Figure 1.21

81. Click Apply and OK.

82. Click Add.

The Add New Attribute dialog box opens.

83. Enter RestrictedTurns in the Name field.

84. For Usage Type, select Restriction.

85. Leave Prohibited for Restriction Usage.

This setting prohibits the intersection of rotation objects during analysis.

86. Note that the Use by Default option must be enabled. This constraint is used by default when creating a new network analysis layer. If you want to ignore the limitations when performing the analysis, enable it in the analysis settings (Fig. 1.23).

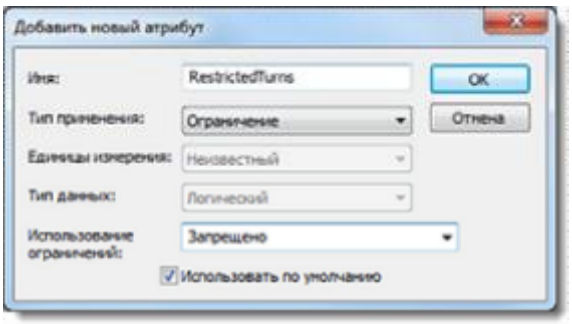


Figure 1.23

87. Click OK.

New attribute Restricted rotations added to the attribute list. A blue circle with the letter D inside indicates that the attribute is enabled by default in new analyzes.

88. Click Evaluators to assign a source value to the new attribute.

89. To set the rating type for the Restricted Turns attribute to Constant, follow these steps:

a) In the Attribute list, select Restricted Turns;

b) In the Restricted Turns line, click under the column

on Type and select Constant from the drop-down list;

c) Click on the Value column and select Use Restriction.

The result should look like this (Fig. 1.24):

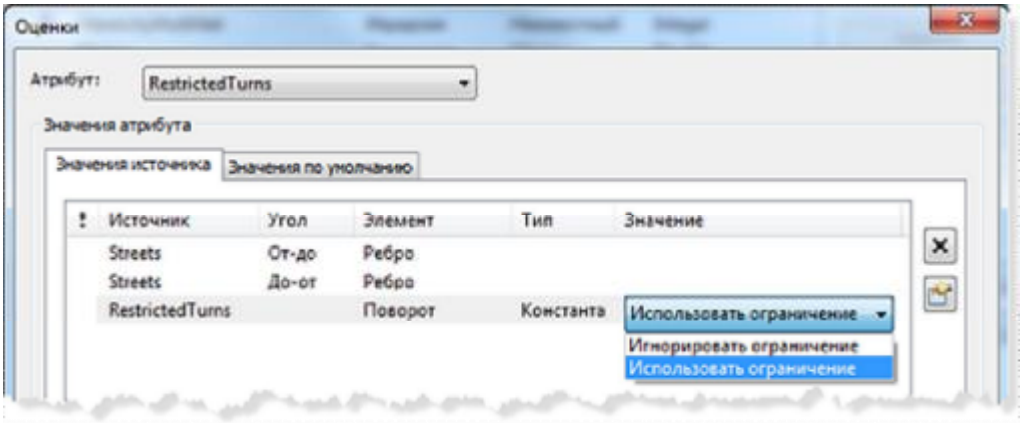


Figure 1.24

After that, by default, Network Analyst will not manage any of the objects in the Restricted Turns object class. This technique is a good way to simulate incorrect or dangerous turns that should be avoided. Estimates for street sources have not been set, so they will remain passable when using Restricted Turns.

91. Click OK to return to the New Network Dataset wizard.

The result should be as follows (Fig. 1.25):

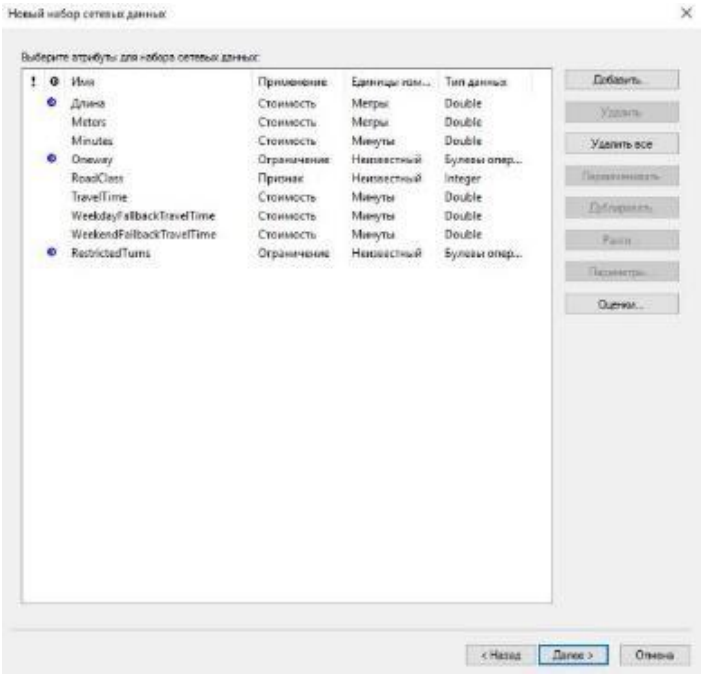


Figure 1.25

92. Click Next.
93. In the Mode of movement value, enter Streets.
94. Under Type, select Automobile.
95. In the Impendace value, select Meters.
96. In the Attribute time value, select Travel Time (Fig. 1.26).

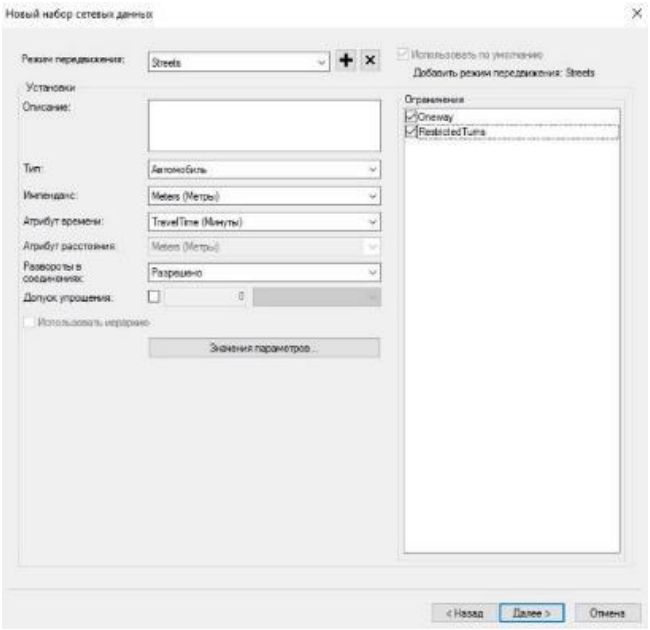


Figure 1.26

97. Click Next.

98. To adjust the track sheet, click Yes (Figure 1.27).

Figure 1.27

99. Click on Directions.

The Network Direction Properties dialog box opens.

Now you need to specify the fields for the travel letter, which belongs to the results of network analysis.

100. Make sure the Name field is on the General tab (Name) Primary lines are automatically associated with the Name_RUS element.

The Name field (NAME_RUS) contains the names of the streets of Kharkiv needed to generate directions.

The result should look like this (Fig. 1.28):

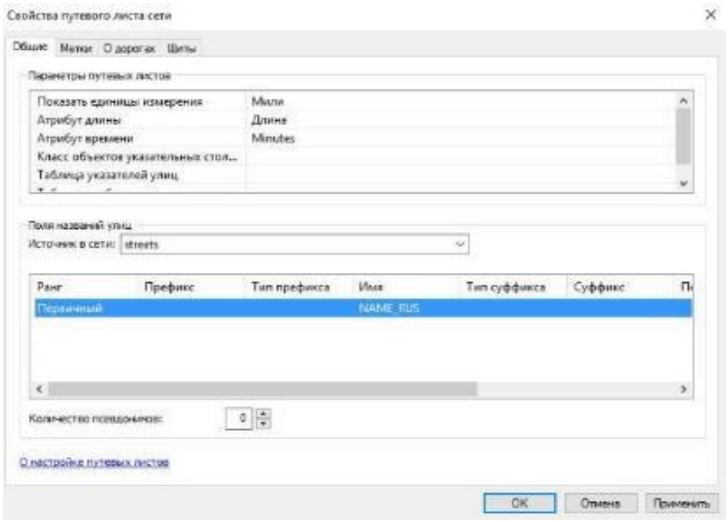


Figure 1.28

Click Apply and click OK.

101. Click Next.

102. Click Next.

103. Click Finish.

104. Click Yes.

After creating the network, the system will issue a request to build it. In the process of construction, the connected elements of the network are defined and the attributes of the network data set are filled. Network construction is applied before performing any network analysis operations.

105. Click Yes.

The Build Network Dataset process indicator will appear, it will disappear after the build process is completed (Fig. 1.29).

Figure 1.29

A new network data set (Streets_ND) has been added to the directory

ArcCatalog simulta neously withclass objects system nodes Streets_ND_Junctions.

103. You can preview a set of network data by clicking on the name of the set and then on the Preview tab.

The ribs will be displayed, and then traffic will be assigned.

104. Close the ArcCatalog.

The created set of network data meets certain requirements, it can be added to ArcMap and used for network analysis.

1.2 Creating a multimodal network data set

In addition to these methods, connectivity is provided by creating multimodal transport networks. The network data set also includes many network attribute models, which allows you to model the impedance, constraints and hierarchy of the network. In ARC / INFO, coverage was used to quickly create networks. In ArcView GIS, during the first network analysis, a permanent network was created for the linear shapefile. In ArcGIS, a persistent network is stored in a network dataset. You can save this network, change its properties, or simulate other networks using network datasets. There are several ways to create a network data set. It is best to create a network data set from object classes in the geodatabase object data set. Because an object data set can be stored and interact seamlessly with multiple classes of spatial objects, a network data set can support multiple sources and simulate a multimodal network. Shapefile-based network datasets allow ArcView GIS users to transfer data quickly. A shapefile network data set is created from a polyline shapefile file that contains a network source (such as a street network) as well as a shapefile spatial object class. This set of network data does not support multi-edge sources. It also cannot be used to model multimodal networks. The ArcGIS Network Analyst extension plug-in can read SDC network datasets. This allows you to perform network analysis of SDC data provided by the provider without the need to create your own set of network data.

We will describe the technology of creating a multimodal set of network data for the transport network of Kharkiv. To do this, we use geographical information about the streets and intersections of the city, as well as subway lines, and obtain data for multimodal analysis.

Let's start the network data set wizard.

1. Activate the ArcGIS Network Analyst plug-in by following these steps:

a) click on Settings(Customize)> Additional modules (Extensions). The Extensions dialog box opens;

b) mark ArcGIS Network Analyst;

c) click Close.

2. If you have not already been connected to the Network Analyst Wizard folder, you need to get up by following these steps:

a) on the Standard toolbar, click the Connect To Folder button. A dialog box opens Connect To Folder;

b) go to the folder with the materials of the Network Analyst module;

c) click OK.

The shortcut for this folder will be added to the Catalog Tree under the Folders Connection heading.

3. IN Trees catalog (Catalog Tree) deploy the node... \…> Kharkivgdb.

4. Click on the Transportation feature set.

The classes of spatial objects contained in it are listed on the Contents tab in ArcCatalog.

5. Right-click the Transport feature set (Transportation) and New> Network Dataset (Fig. 1.30).

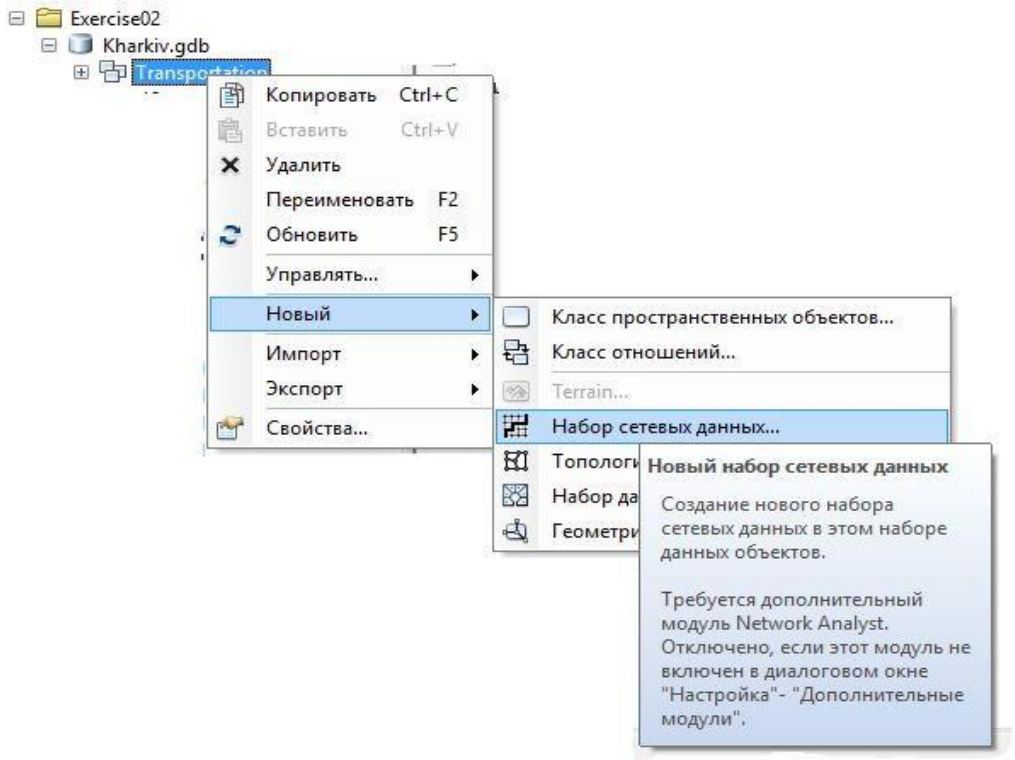


Figure 1.30

The New Network Dataset wizard opens.

The name of the network and the choice of source classes of spatial objects Steps:

1. Enter Kharkiv Multimodal as the network dataset name (Fig. 1.31).

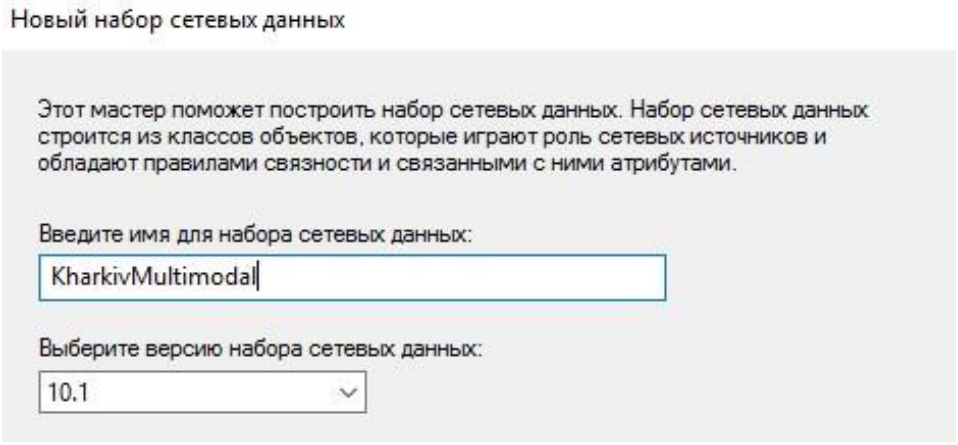


Figure 1.31

The Select a version for your network dataset option must be set to the latest version.

This option is useful when hosting network datasets for users who have earlier versions of ArcGIS. They will be able to open a network dataset created and shared for public if a version number less than or equal to their ArcGIS version number is selected. The disadvantage of this choice is that the new network data set cannot include the functionality that appeared in the new versions of ArcGIS, because the controls for adding these functions in the New Network Dataset wizard will be inactive. If you do not need to share the network data set, or if users who have access to it have the same versions of ArcGIS, it is best to choose the latest version.

2. Click Next.

A wizard page appears to select the feature classes that participate in the network data set.

3. Click on Choose all (Select All) for choice all classes of spatial objects so that they perform the function of sources in the network (Fig. 1.32).

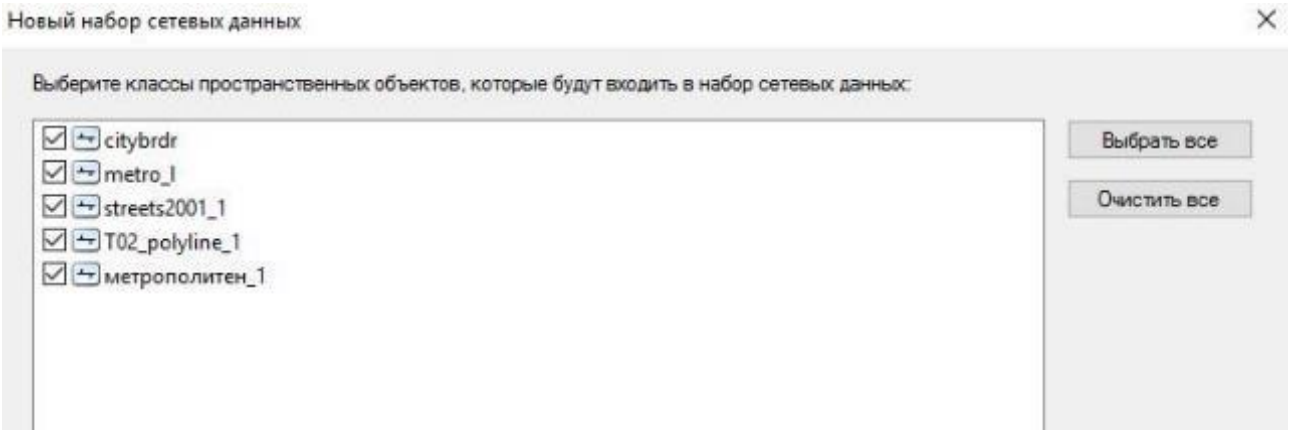


Figure 1.32

4. Click Next.

5. Click Yes to simulate network turns.

6. Although there are no rotation object classes for this network, selecting Yes allows the network data set to support shared rotation and allows rotation objects to be added at any time after the network is created. 1.33).

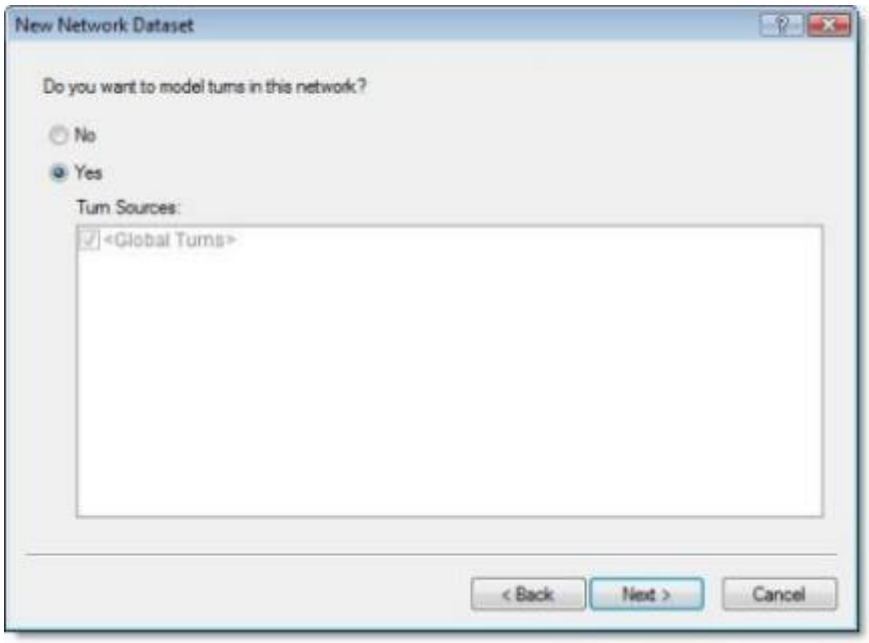


Figure 1.33

7. Click Next.

The connectivity setup page is displayed.

Connectivity settings and terrain rules

The connectivity settings in the ArcGIS Network Analyst plug-in start with defining connectivity groups. The sources of the edges are determined relative to one or more groups of connectivity. The connectivity group can contain any number of sources. The connection of network elements is determined by the connectivity group of the element. For example, two edges created from two separate source object classes can be connected if they belong to the same connectivity group. If the edges belong to different connectivity groups, then the edges to be connected are not joined by a connection that participates in both connectivity groups.

Connectivity groups are created by following these steps:

1. Click Connectivity to configure the network connectivity model; the Connectivity dialog box opens.

2. Click once on the up arrow on the Group Columns to increase the number of connectivity groups to two. The column for the second connectivity group is created in the Connectivity Groups table. In this exercise, the connectivity group (1) is the metro system and the group (2) is the street network.

3. Click on the Streets line (Streets2001_1) and check the column labeled 2 to move the street source to connectivity group (2) (Figure 1.34).

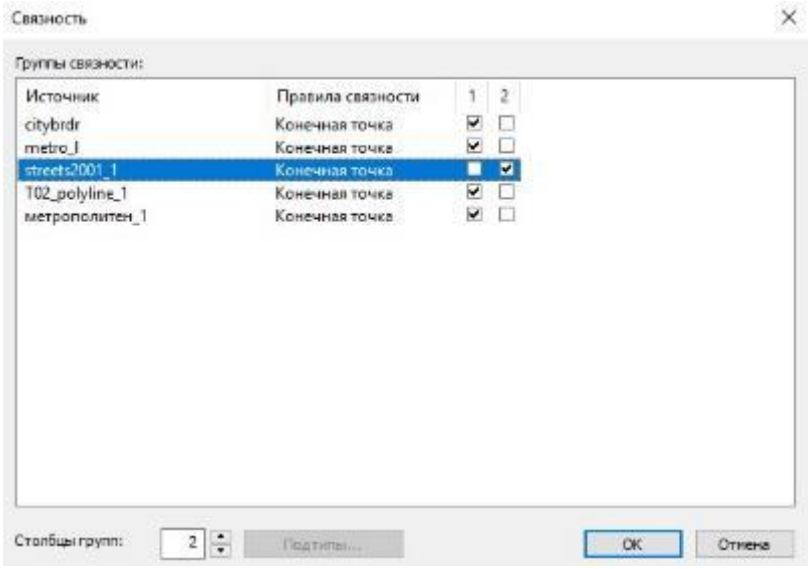


Figure 1.34

4. Click OK to return to the New Network Dataset wizard.

5. Click Next.

Terrain settings in the network data set further determine network connectivity. Let's show it by an example. Suppose that two edges have endpoints that coincide in coordinates X, Y, but have different heights (one endpoint is located above the other). In addition, assume that the connectivity method is set for Endpoints. If the heights of the points do not matter, the edges are connected. On the other hand, if the heights are taken into account, they will not connect.

There are two ways to model the terrain: using true values of geometry heights or using logical values of heights in height fields.

6. There is no terrain data for this data set, so you need to click on None (Fig. 1.35).

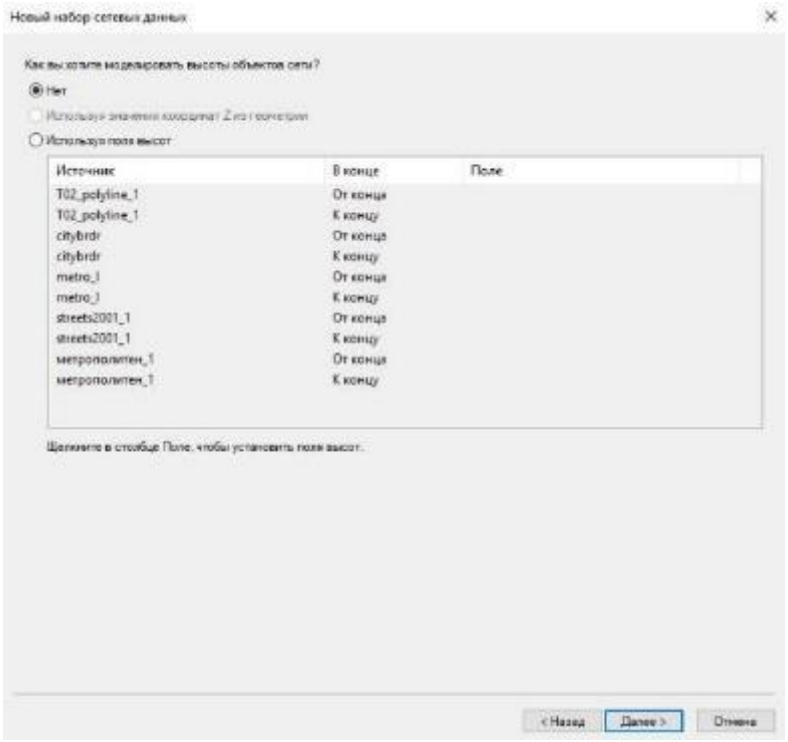


Figure 1.35

7. Click Next (Fig. 1.36).

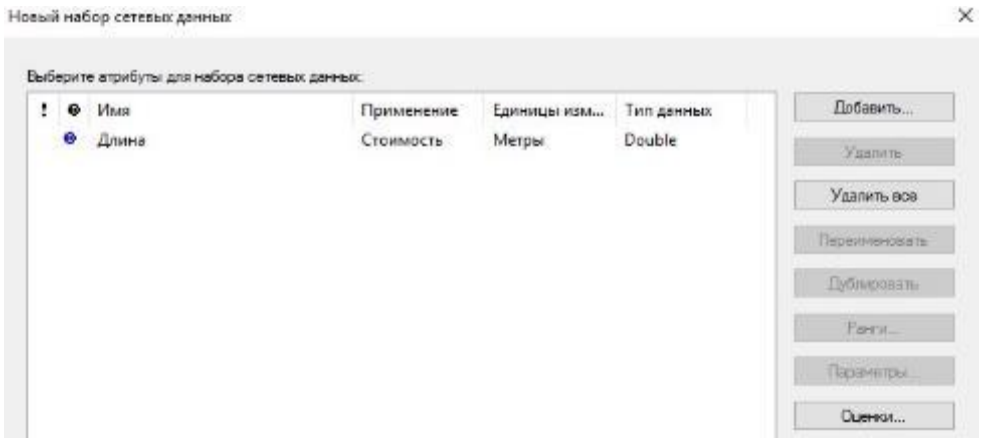


Figure 1.36

8. Click Add. The Add New Attribute dialog box opens.
9. Enter Meters in the Name text box.
10. Set the Usage Type to Cost.
11. Change Units to Meters.
12. Set the Data Type to Double Precision Number.

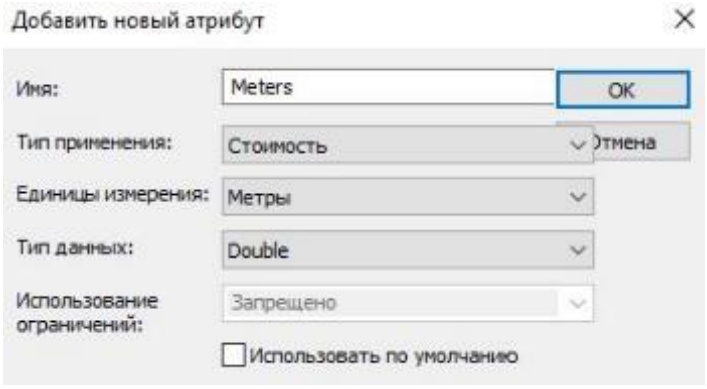


Figure 1.37

13. Click OK (Fig. 1.38).

Figure 1.38

14. Click Add.
15. Enter Minutes in the Name text box.
16. Set the Usage Type for Cost.
17. Change Units to Minutes.
18. Set the Data Type to Double Precision Number (Figure 1.39).

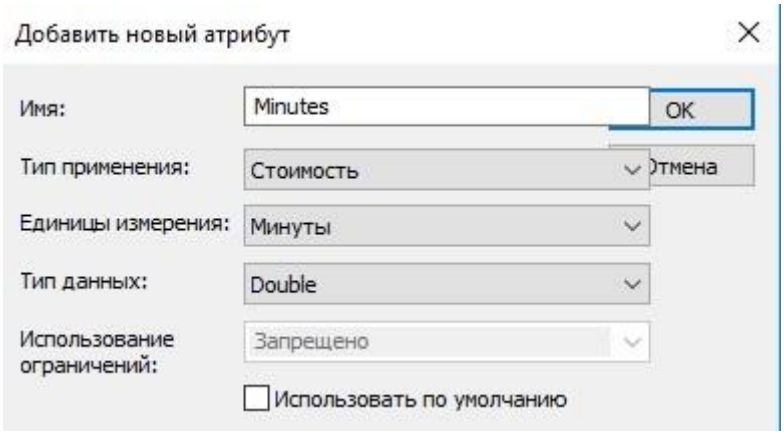


Figure 1.39

19. Click OK.
20. Click Add. The Add New Attribute dialog box opens.
21. Enter Oneway in the Name field.
22. For Usage Type, select Restriction.
23. Leave the Data Type Prohibited (Fig. 1.40).

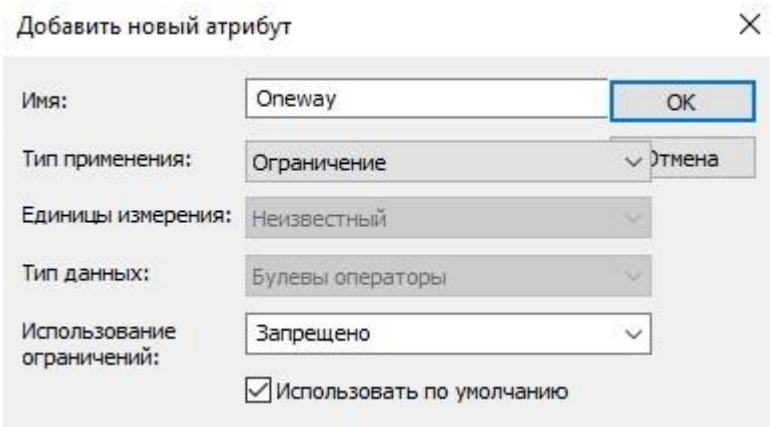


Figure 1.40

24. Click OK.
25. Click Add. The Add New Attribute dialog box opens.
26. Enter RoadClass in the Name field.

27. For Usage Type, select Descriptor.

28. For Units, select Uknown.

29. Click Integer Data Type (Figure 1.41).

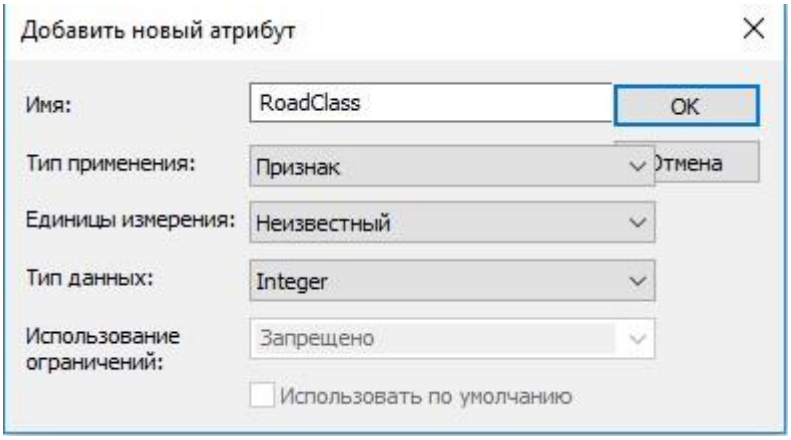


Figure 1.41

30. Click OK.

The wizard displays the attributes of the network data set (Fig. 1.42).

Figure 1.42

Verify and create network attributes

The purpose of this network data set is to simulate travel time on foot and by car. This will allow you to choose one of two values based on time spent when performing online analyzes. For example, you can answer the question of which route from point A to point B is the shortest for a pedestrian walking on the streets and taking the

subway, or which route is the shortest for a person traveling by car. To perform this task, you must configure attributes for two time values: Pedestrian Time and Drive Time.

Steps:

1. The Minutes attribute, which Network Analyst automatically identifies in the source data, indicates the time of the trip, so you can change its name to a clearer one.

2. Select the Minutes line, click Rename, enter the Drive Time and press ENTER (Fig. 1.43).

Figure 1.43

Next you need to create the Pedestrian Time attribute.

3. Click Add. The Add New Attribute dialog box opens.

4. Enter PedestrianTime in the Name text box.

5. Set the Usage Type for Cost.

6. Change Units to Minutes.

7. Set the Data Type to the Double Precision Number (Fig. 1.44).

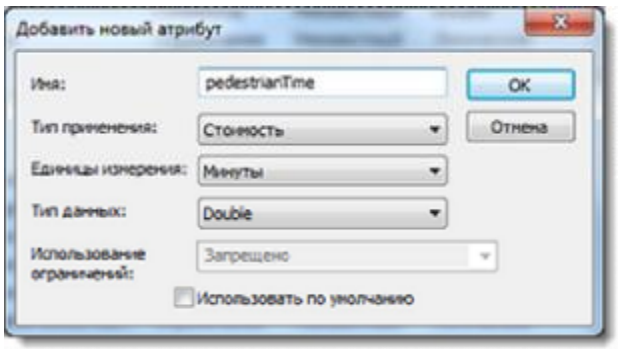


Figure 1.44

8. Click OK.

9. The Add New Attribute dialog box closes, and Pedestrian Time is added to the attribute list.

The three cost attributes, Meters, Drive Time, and Pedestrian Time, are marked with yellow symbols to warn of potential problems with valuation features that determine how network attribute values should be calculated.

The following three sections describe the evaluation setup process.

Meter evaluation settings

This section and the following sections describe the process for setting up estimates. The Meters calculates the distance value for the edges of the network, thus determining the length of the edge.

Steps:

1. Click on Meters and click on Evaluators (Fig. 1.45).

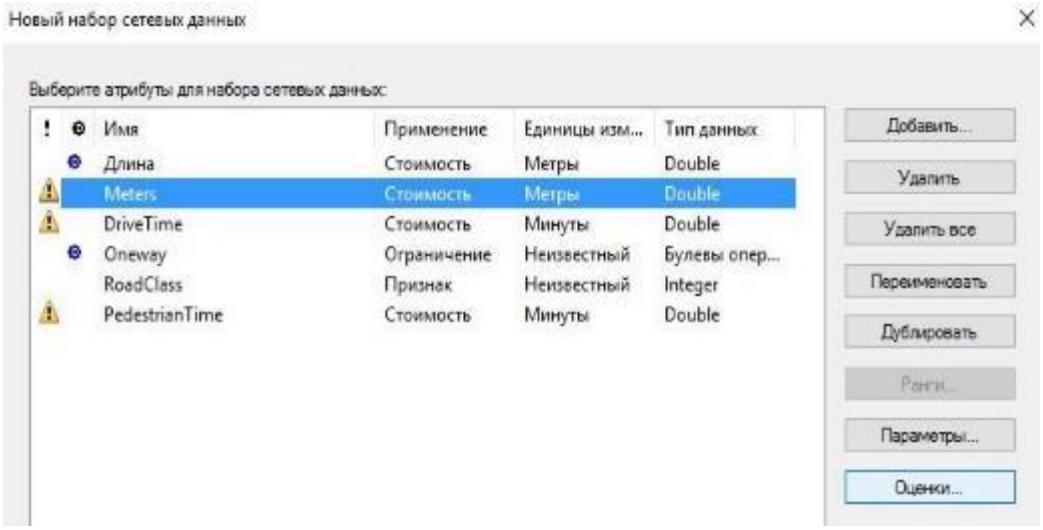


Figure 1.45

The Evaluators dialog box opens. It allows you to view or edit the type of evaluation and its value for each source on the network. It is clear that the sources of connections and turns always have one related evaluation function, while the sources of edges - two: one for each direction of movement (directions "from - to" and "to - from").

2. While holding down the SHIFT key, click on the lines citybrdr From - To (From - To) and then click on the term citybrdr To - From, metro_l (From - To) and metro_l To - From, streets2001_1 (From - To); then click on the term streets2001_1 (To - From), T02_polyline_1 (From - To); on the term T02_polyline_1 (To - From), metro_1 (From - To); further on the term subway_1 (To - From).

Eight lines with warning symbols will be selected.

3. Right-click on any of the selected rows and select Type> Field (Fig. 1.46).

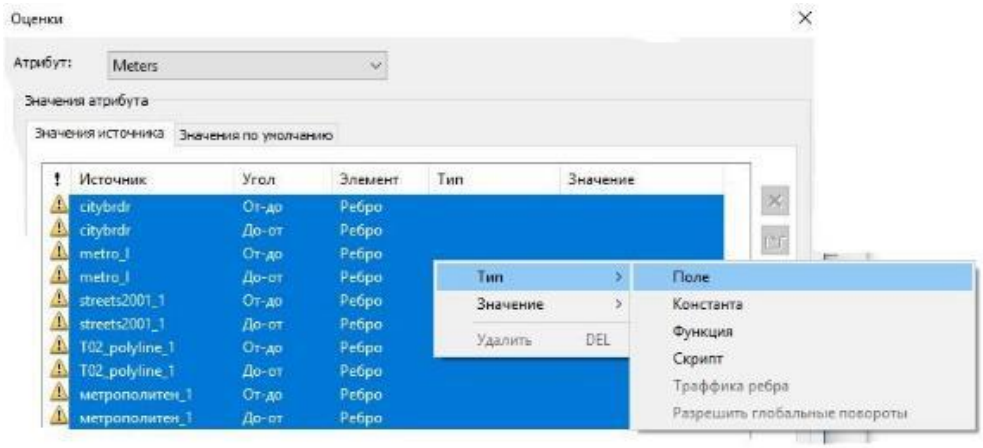


Figure 1.46

Warning symbols change to red error symbols, which indicate incomplete assignment of values by field estimates.

4. Without deselecting eight lines, right-click on one of them on the side of the fields and select Value> SHAPE_LENGTH (Fig. 1.47).

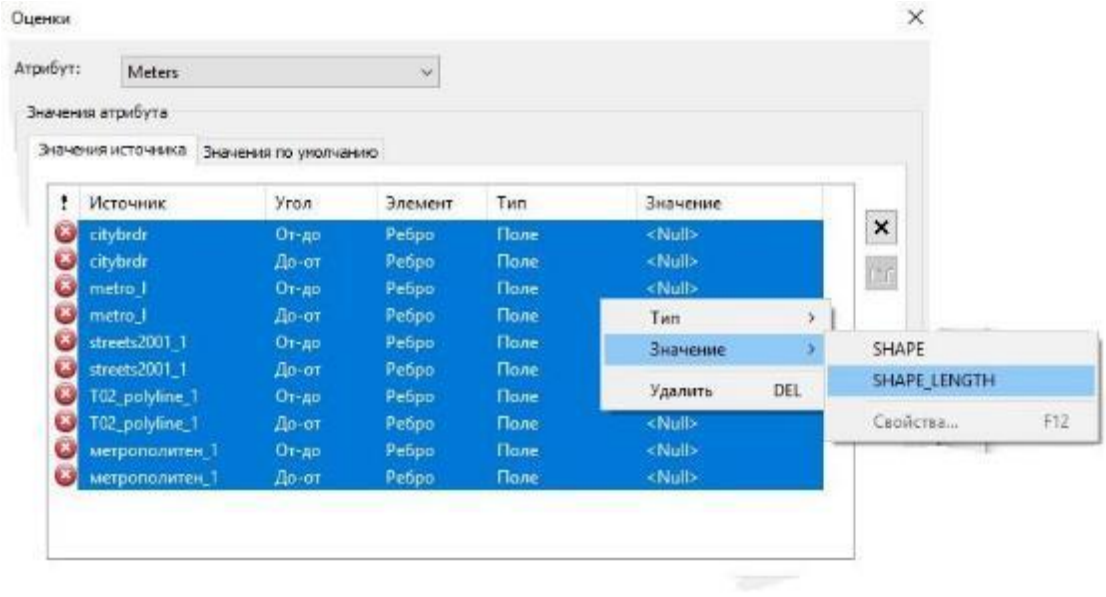


Figure 1.47

This assigns values from the SHAPE LENGTH field in the selected source feature classes for the Meters attribute relative to the associated edge elements of the network.

5. Click the Apply button.

6. The Meters network attribute is configured to obtain a length value.

Configure the Drive Time evaluation function (Travel by car) and One way (One way)

Because cars only move on the streets, estimates for different sources need to be adjusted accordingly.

Steps:

1. In the Attribute list, select Drive Time.

Drive Time values for the Street source were automatically set by Network Analyst, but other edge sources are marked with warning symbols because their values have not been set. These sources should be marked as limited. In addition, metro stations should be limited in such a way as to prevent the location of new network analysis facilities in their area.

2. Click Evaluators.

3. Use the CRTL key to select streets2001_1 From-To and streets2001_1 (To-From), click Type and select Field, and select LENGTH (Figure 1.48) and Value.

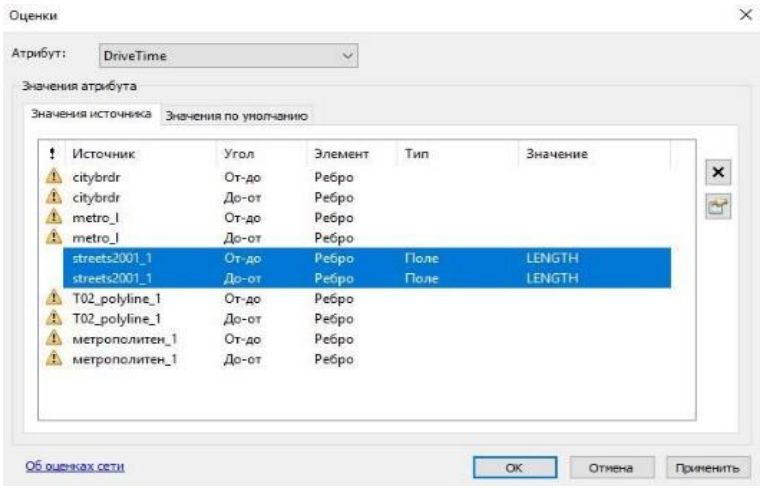


Figure 1.48

4. Select all the last rows by clicking on one of the rows, and while holding down the CTRL key, select the other rows by clicking

(Fig. 1.49).

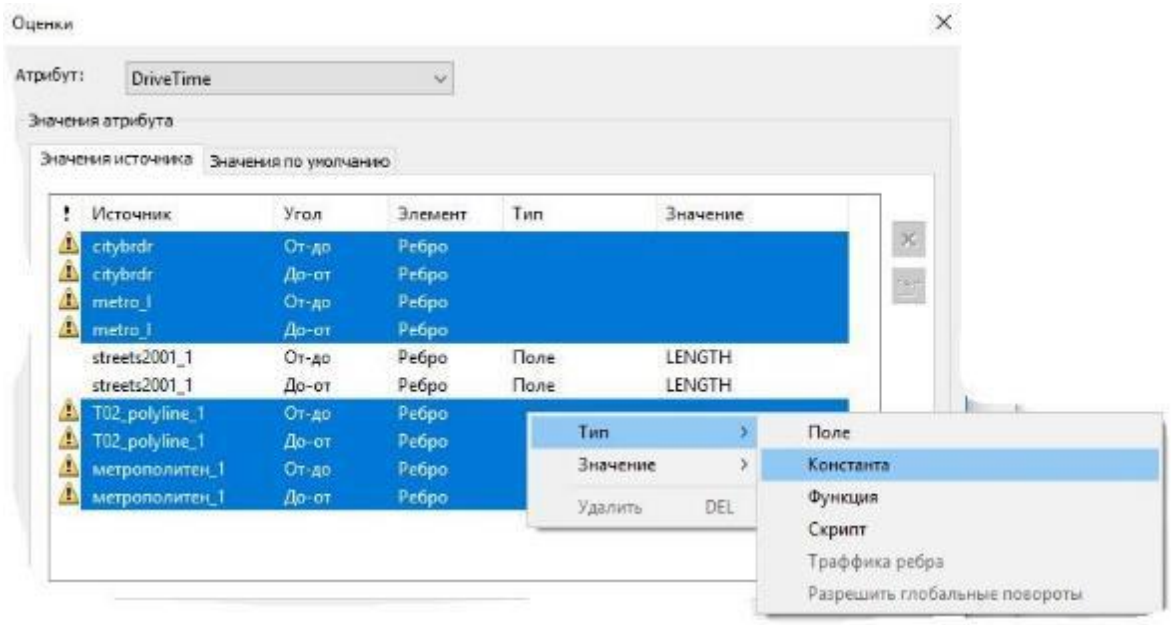


Figure 1.49

5. Right-click on any of the selected rows and on the constant Type> Constant.

6. Right-click one of the selected rows again, but this time Value> Properties.

The Constant Value input window appears.

7. Type -1 and click ENTER.

The values for all selected rows change to -1. Network Analyst considers all items with a value of -1 limited. Whenever the Drive Time attribute is used as an impedance in network analysis, these sources are impassable (Fig. 1.50).

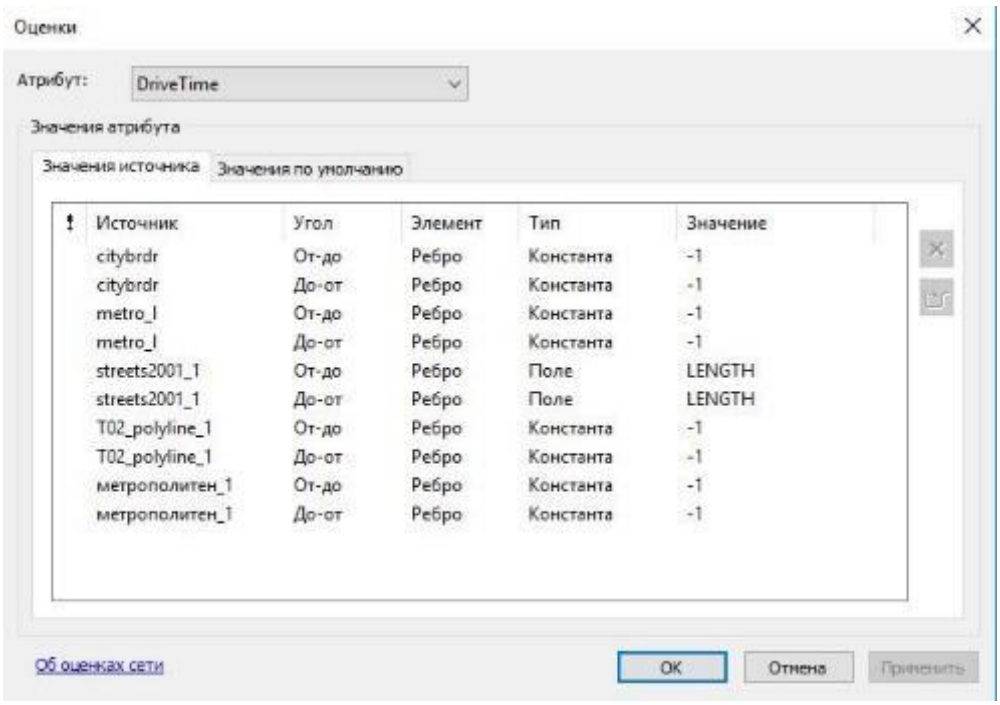


Figure 1.50

8. Click Apply, and then click OK.

The One way attribute is weakly related to the Drive Time attribute, because it simulates the one-way traffic restrictions that drivers are required to adhere to. Later, in the process of conducting an analysis using Drive Time as a cost, it is necessary to enable the One way constraint, so that one-way streets are taken into account during route formation. On the other hand, one way restrictions cannot be used when modeling pedestrian traffic, as pedestrians can move in any direction.

Pedestrian Time Estimation Settings

The Pedestrian Time network attribute indicates the time in the network that a pedestrian spends on the road. At this stage, it is necessary to assign an appropriate travel time for a pedestrian who can travel on the subway or move through the streets.

Steps:

1. From the Attribute list above the dialog box, select Pedestrian Time, and then click Evaluators.

2. Select two citybrdr values (citybrdr To-from, citybrdr From-to), right-click on one of the selected rows and in the field Type (Field)> Field (Field), and in the Value column, select CITYBRDR_I

(Fig. 1.51).

Figure 1.51

3. Select two metro_l values (metro_l To-from, metro_l From-to), right-click on one of the selected rows and in the field Type> Constant> Constant, and in the value column (Value) select 0 (Fig. 1.52).

Figure 1.52

4. Select the two values streets2001_1 (streets2001_1 To-from, streets2001_1 From-To), right-click on one of the selected rows and the field Type> Field (Field), and in the column Value, select LENGTH (Fig. 1.53).

Figure 1.53

5. Select two values T02_polyline_1, right-click on one of the selected rows and the field Type> Field (Field), and in the column Value (Value) select ID (Fig. 1.54).

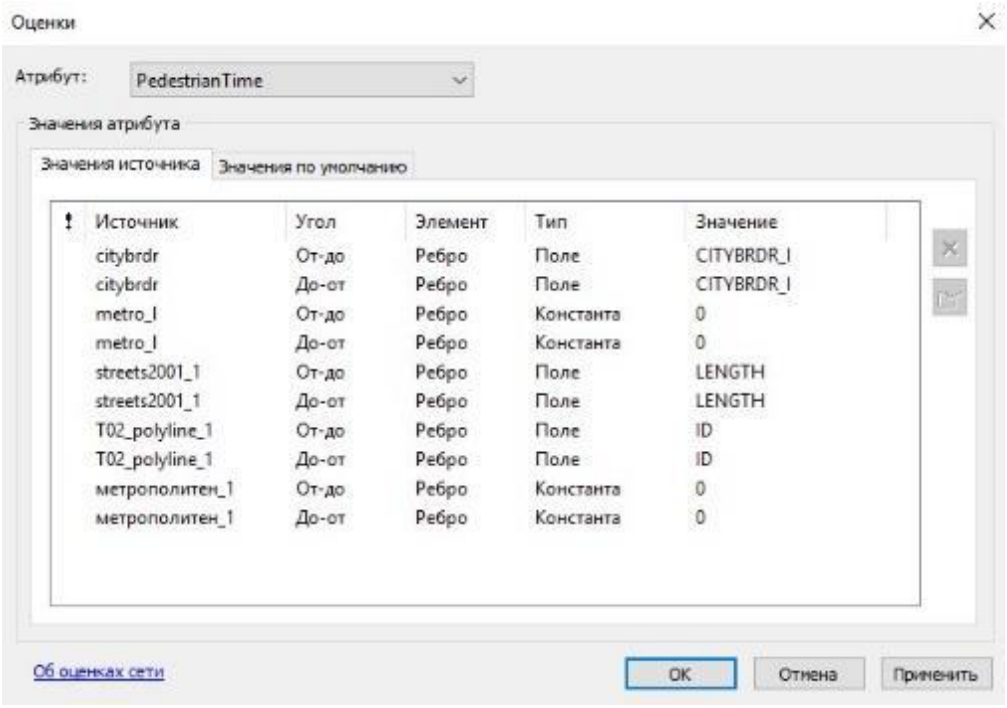
Figure 1.54

6. Select two values of metro_1, right-click on one of the selected rows and in the field Type (Type)> Constant (constant), and in the column Value (Value) select 0 (Fig. 1.55).

метрополитен_1	From-To	Edge	Constant	0
метрополитен_1	To-From	Edge	Constant	0

Figure 1.55

The result should be as follows (Fig. 1.56):



Источник	Угол	Элемент	Тип	Значение
citybrdr	От-до	Ребро	Поле	CITYBRDR_I
citybrdr	До-от	Ребро	Поле	CITYBRDR_I
metro_I	От-до	Ребро	Константа	0
metro_I	До-от	Ребро	Константа	0
streets2001_1	От-до	Ребро	Поле	LENGTH
streets2001_1	До-от	Ребро	Поле	LENGTH
T02_polyline_1	От-до	Ребро	Поле	ID
T02_polyline_1	До-от	Ребро	Поле	ID
метрополитен_1	От-до	Ребро	Константа	0
метрополитен_1	До-от	Ребро	Константа	0

Figure 1.56

7. Click the From Streets line to select it. Hold down the CTRL key, click the Streets To-From line to select both lines.

8. Right-click on one of the selected rows and on Value >> Properties.

The Field Evaluators dialog box opens.

For Streets, Pedestrian Time is the walking time. Assume that the pedestrian speed is 3 km / h, the travel time in minutes will be [LENGTH] * 60/3000, where [LENGTH] is an attribute containing the length of the rib in meters.

9. Double-click the LENGTH field to move it to the Value = text box, and enter the expression [LENGTH] * 60/3000 in the Field Evaluators dialog box (Figure 1.57).

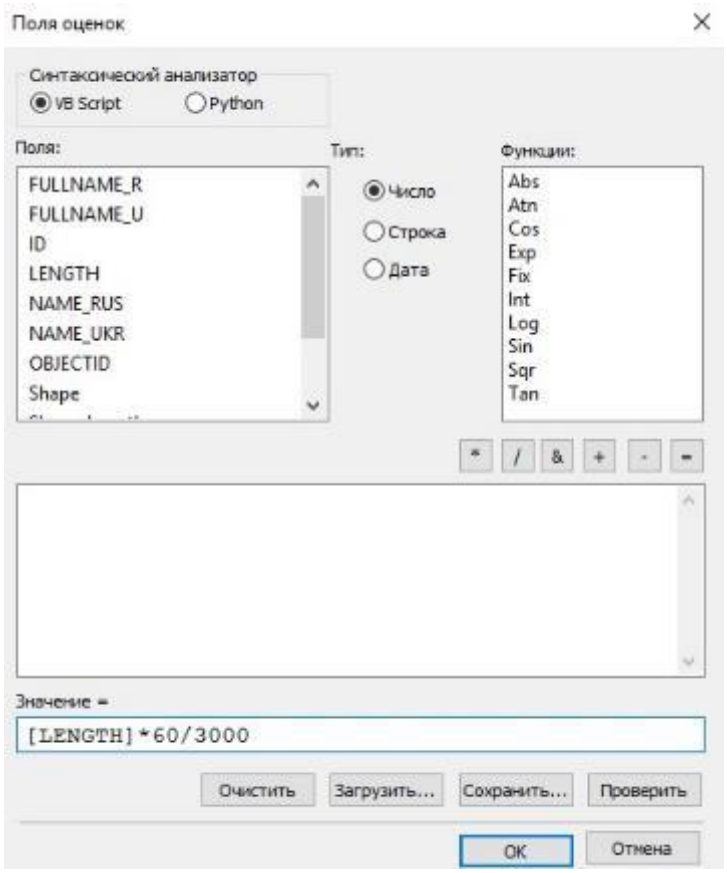
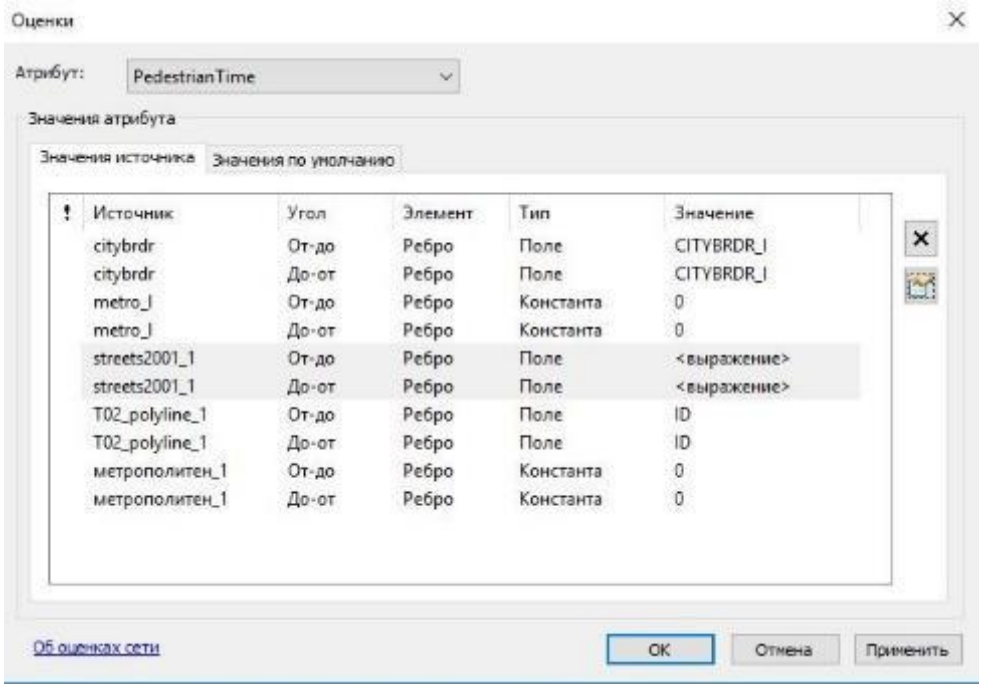


Figure 1.57

10. Click the Verify button to make sure the expression is correct and correct it if necessary.

11. Click OK to return to the Ratings dialog box (Evaluators) (Fig. 1.58).



!	Источник	Угол	Элемент	Тип	Значение
	citybrdr	От-до	Ребро	Поле	CITYBRDR_I
	citybrdr	До-от	Ребро	Поле	CITYBRDR_I
	metro_l	От-до	Ребро	Константа	0
	metro_l	До-от	Ребро	Константа	0
	streets2001_1	От-до	Ребро	Поле	<выражение>
	streets2001_1	До-от	Ребро	Поле	<выражение>
	T02_polyline_1	От-до	Ребро	Поле	ID
	T02_polyline_1	До-от	Ребро	Поле	ID
	метрополитен_1	От-до	Ребро	Константа	0
	метрополитен_1	До-от	Ребро	Константа	0

Figure 1.58

12. Click OK to return to the New Network Dataset wizard.
13. Click Next.
14. In the Mode of movement, enter Streets. Press ENTER.
15. Select Automobile as the Type value.
16. Select Meters as the Impendace value.
17. Select Drive Time as the Attribute time value (Figure 1.59).

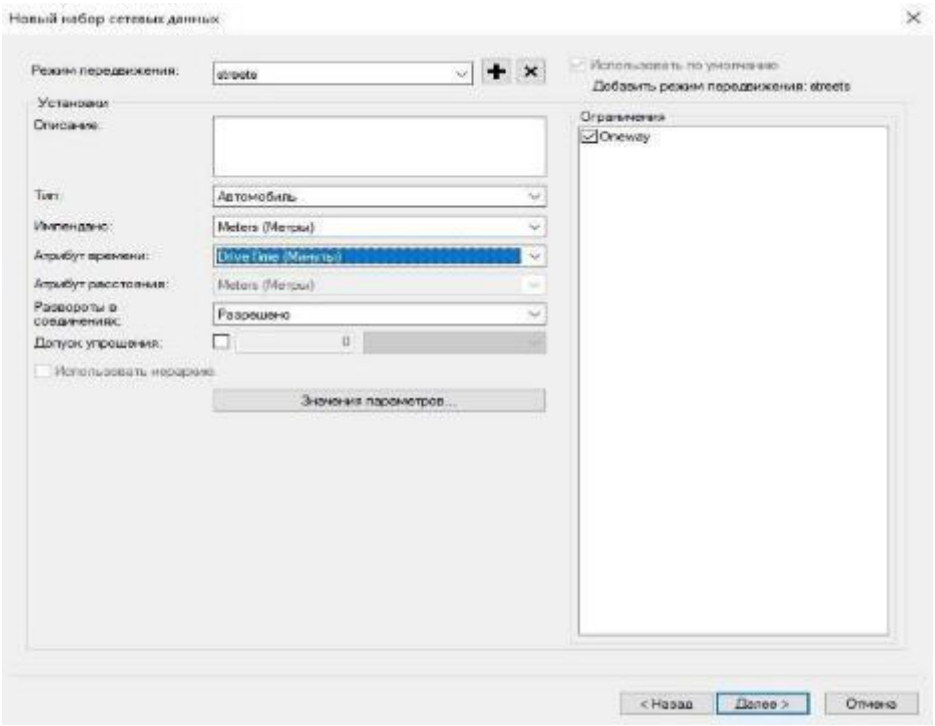


Figure 1.59

18. Click Next.

Setting directions

After calculating the routes in the selected network data set, you can determine the direction of travel to track the results. The network data set must have at least one edge source with a text attribute (for street name information) and a distance attribute to determine the distance to which the next maneuver is to be performed.

Steps:

1. Click Yes to adjust the track sheet.
2. Click on Directions. The Network Direction Properties dialog box opens.

3. Specify fields for compiling a travel letter, which is one of the results of network analysis. On the General tab, in the Source list, select Streets2001_1 (Figure 1.60).

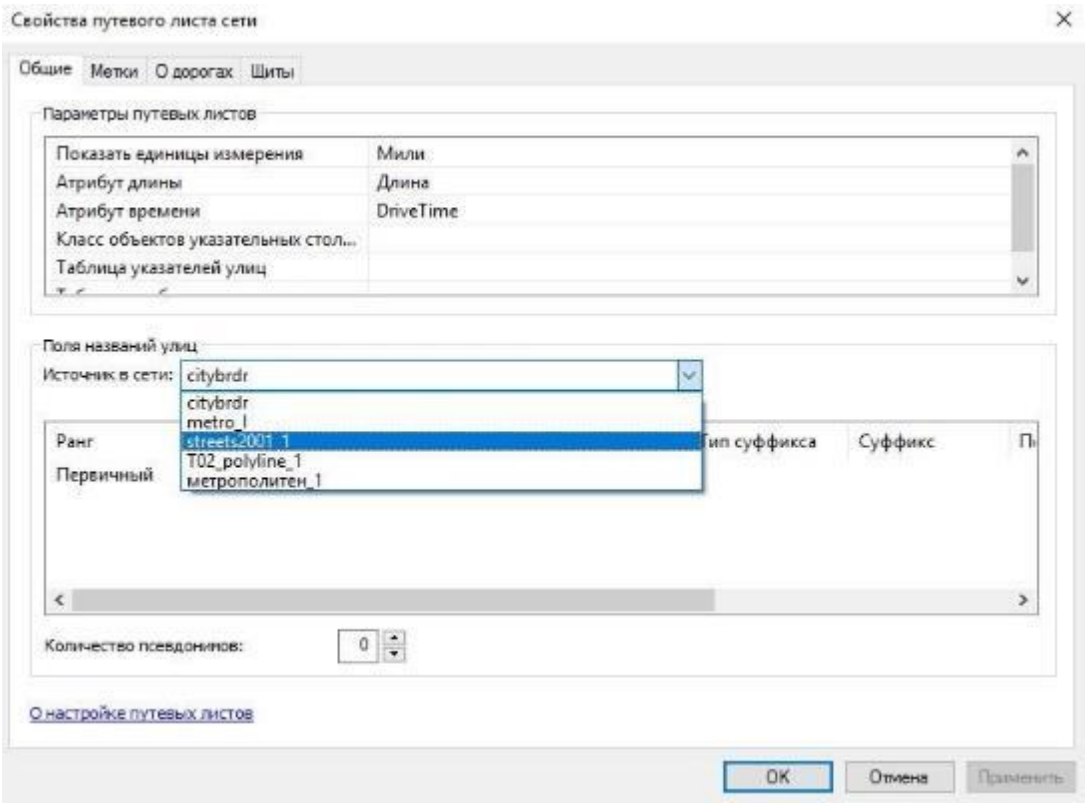


Figure 1.60

4. In the Street Name Fields list, click Primary to select.

5. Click on the Name column and select Name_RUS

(Fig. 1.61).

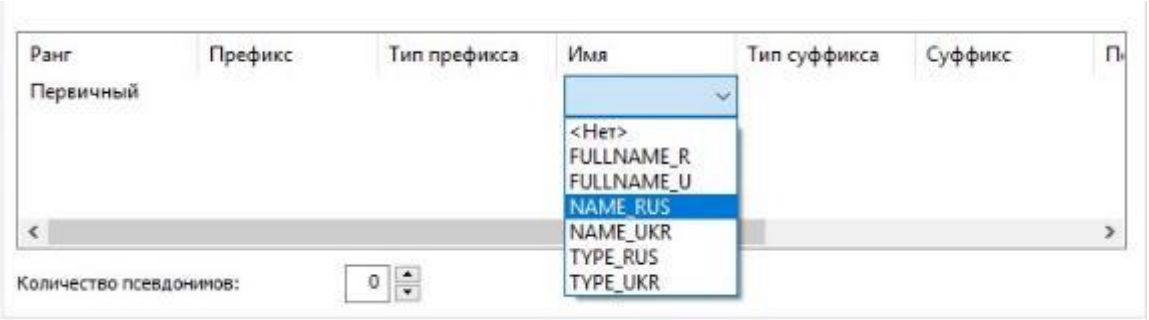


Figure 1.61

6. Click OK to return to the New Network Dataset wizard.

7. Click Next.

8. Click Next.

This will display summary information for all settings.

Creating and building a network data set

After setting the values required for the network data set to function, you need to create and build the set. The creation process is fast and usually creates a container for the logical network.

Steps:

1. Click Finish.

A process indicator will appear, which allows you to monitor the process of creating a set of network data in the Network Analyst module (Fig. 1.62).

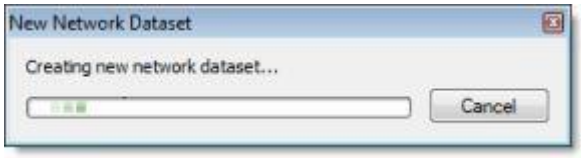


Figure 1.62

After creating the network, the system will issue a request to build it. In the process of construction, the connected elements of the network are defined and the attributes of the network data set are filled. You need to build a network before performing any network analysis operations.

2. Click Yes.

The Build Network Dataset process indicator will appear (Fig. 1.63); after the construction process it will disappear.

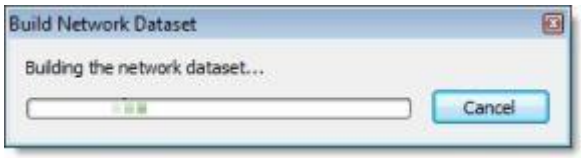


Figure 1.63

A new set of network data - KharkivMultimodal_ND has been added to the ArcCatalog at the same time as the spatial object class of the KharkivMultimodal_ND_Junctions system nodes.

You can preview a set of network data by clicking on the name of the set and then on the Preview tab.

3. Close the ArcCatalog.

1.3 Search for the optimal route using a set of network data

This section clarifies the solution of the problem of constructing the shortest route from the starting and intermediate points in the city of Kharkiv.

1. Activate the ArcGIS Network Analyst plug-in by running

the following actions:

a) click on Settings (Customize)> Additional modules (Extensions). The Extensions dialog box opens;

b) mark ArcGIS Network Analyst;

c) click Close. If the Network Analyst toolbar isn't already displayed, you'll need to add it;

2. Click Customize> Toolbars> Network Analyst.

The Network Analyst toolbar will be added to ArcMap (Figure 1.64).

Figure 1.64

3. If the Network Analyst window does not yet appear, you need to add it.

On the Network Analyst toolbar, click the Network Analyst window.

The attached Network Analyst window will open (Fig. 1.65).

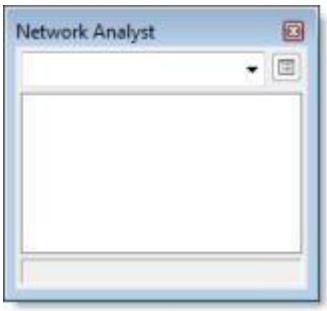


Figure 1.65

The Network Analyst window can be pinned and unpinned.

Create a route analysis layer

Click Network Analyst on the Network Analyst toolbar and click New Route (Figure 1.66).

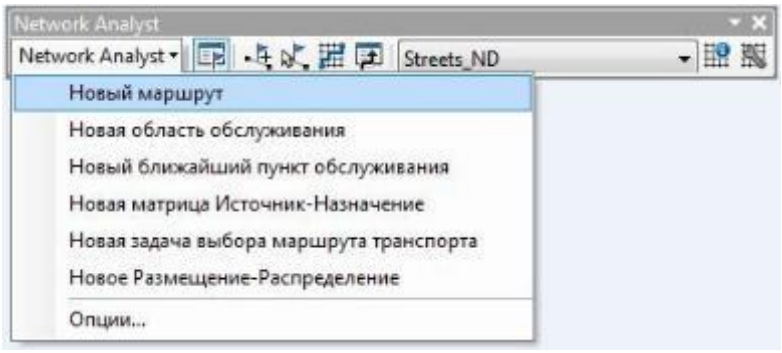


Figure 1.66

The route analysis layer will be added to the Network Analyst window. Classes of network analysis: Stops, Routes, Point Barriers, Line Barriers and Polygon Barriers are empty (Fig. 1.67).

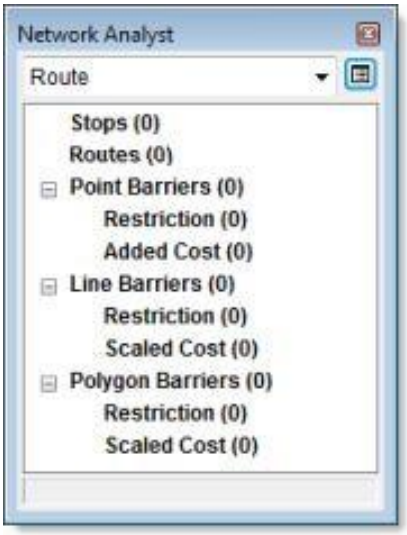


Figure 1.67

Also, a new layer of analysis has been added to the Table Of Contents window (Fig. 1.68).

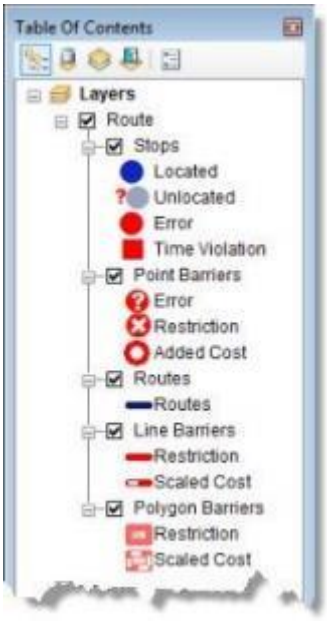


Figure 1.68

Add a stop Then you need to add the necessary stops of the route.

Steps:

1. In the Network Analyst window, click Stops (0).

The choice of stop means that it is placed in the active class of network analysis.

2. On the panel tools Network Analyst click on the map Create Network Location Tool .

You can add network analysis objects to the active network analysis class by clicking on the Create Network Location Tool map.

3. Click anywhere on the street network to determine the new location of the stop (Fig. 1.69).

Figure 1.69

Network Analyst calculates the nearest network location and marks the stop with the Located symbol. The stop remains selected until another stop is placed that is unselected.

The located stop also displays the number 1. All stops are marked with unique numbers that make up the order in which the stops are located along the route. It should be noted that in the list of the Stops class in the Network Analyst window, one stop is specified (Fig. 1.70).

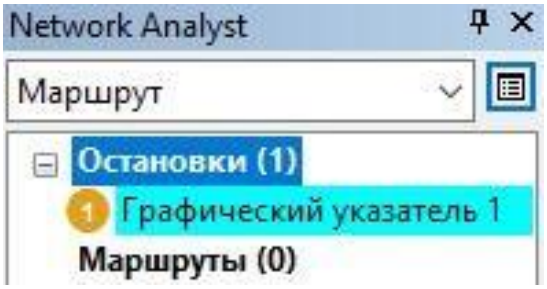


Figure 1.70

4. Add two more stops anywhere on or near the streets (Fig. 1.71).

Figure 1.71

New stops are assigned numbers 2 and 3. The first stop is considered as a starting point, and the last - as a destination (Fig. 1.72).

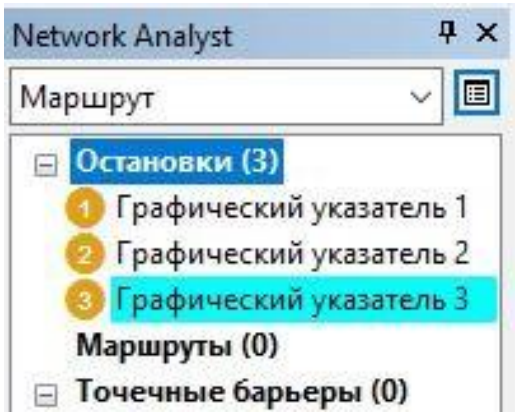


Figure 1.72

You can change the sequence of stops by clicking the stop number on the Network Analyst window and moving it to another position in the list.

If the stop is not placed on the network, it will be displayed with the symbol "not aligned" (however, using the default settings, you must place the stop more than 5 kilometers from the nearest segment of the street so that it is not considered located in Fig. 1.73).

Figure 1.73

An unplaced stop can be moved closer to the network so that it is located. If the stop on the network is placed incorrectly, you can move it to the correct position.

To move a stop, follow these steps:

a) click on Select / Move tool Network Position (Select / Move Network Locations Tool) on the toolbar Network Analyst;

b) click on the stop to select it;

c) click on the stop again and drag it to a new place (Fig. 1.74).

Figure 1.74

Setting analysis parameters

Next, it is necessary to specify that the route will be calculated on the basis of travel time (minutes), that turns can be made arbitrarily, and it is necessary to adhere to one-sided restrictions and restrictions on turning.

Steps:

1. Click the Analysis Layer Properties button in the Network Analyst window (Fig. 1.75).

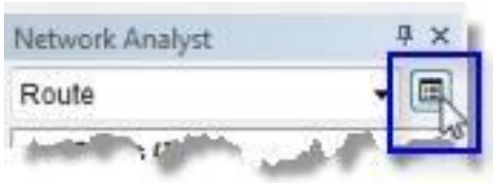


Figure 1.75

The Layer Properties dialog box opens.

2. Click the Analysis Settings tab.

3. Make sure that Impedance is defined as Travel Time (Minutes) (Figure 1.76).

Figure 1.76

This network dataset has a traffic history associated with the TravelTime (Minutes) attribute. If you enter a start time (select Use Start Time and fill in the three fields below it), Network Analyst will search for the optimal route time based on the specified time of day and speed of traffic history. Otherwise, the program will search for the optimal route in time by the function of street lengths and speed limits.

4. Check Use Start Time, enter a specific time and date or day of the week by following these steps:

a) As Time of Day, enter the time when you want to leave the first one stop;

b) select either the Day of Week or the Specific Date.

If Day of Week is selected, specify any day from Monday to Sunday; you can also select Today to use the current system settings.

If Specific Date is selected, enter the date in the text box or drop-down list, open the calendar, and select the desired date.

Do not select the Use Time Windows option.

You can specify temporary windows for stops, in which case Network Analyst will search for a route based on the time ranges during which you should visit certain stops.

Do not select Reorder stops to find optimal route.

If not specified, Network Analyst will calculate the best route with the specified sequence of stops. This is the so-called "salesman's task". If this option is selected, the program will determine the best route and the best the sequence in which the stops will be visited;

c) select Allowed from the Undo in drop-down list U-Turns at Junctions;

d) click the Output Shape Type drop-down arrow and select True Shape with Measures);

e) Make sure that the Use Hierarchy and Ignore Invalid Locations check boxes are selected, and that Restricted Turns and One way are checked in the Restrictions section.

f) set that in the Directions frame, the Distance Units parameter has a value of Kilometers, the Use Time Attribute item has been selected, and the hour attribute has a value of TravelTime (Minutes).

The Analysis Settings tab might look like this; however, you can turn other authorities on the cob Use Start Time (Fig. 1.77).

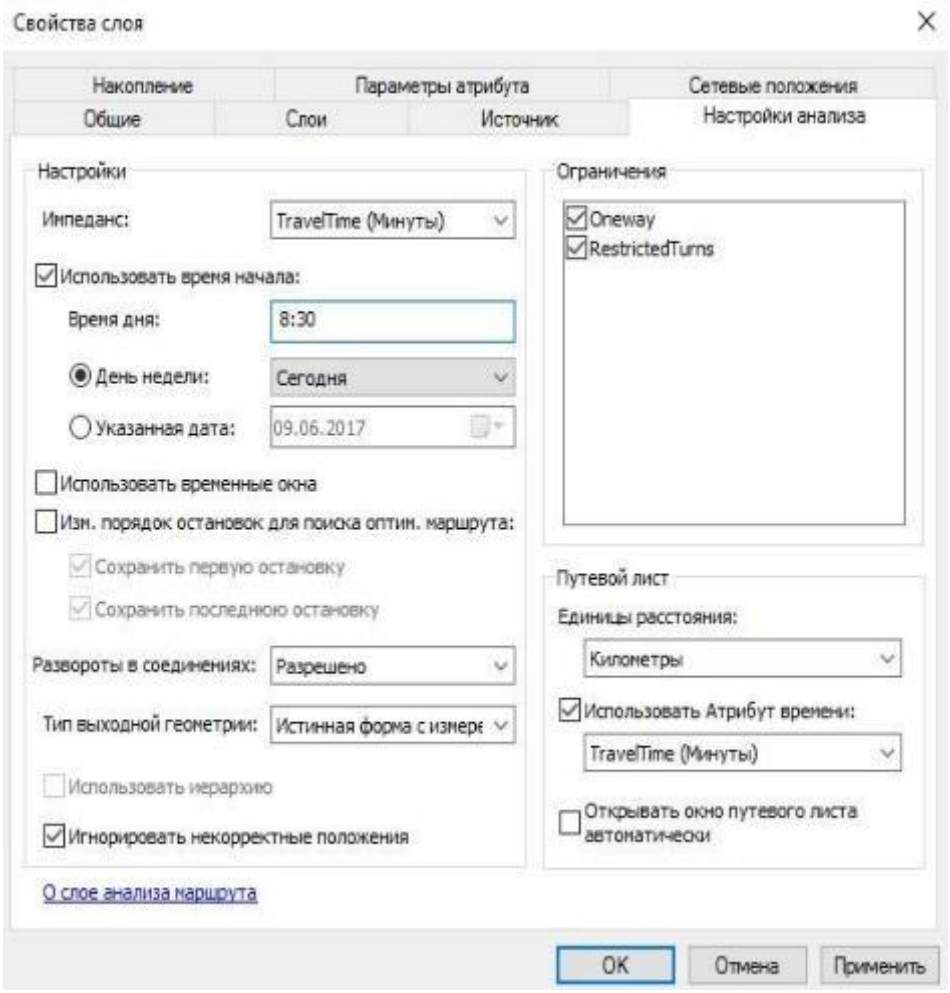


Figure 1.77

g) press OK.

Calculation of the most optimal route

Steps:

1. Click the Solve button on the Network Analyst toolbar.

The route object will appear in the map document and in the ArcGIS Network Analyst window under the Routes class (Figure 1.78).

Figure 1.78

If a warning appears, the stop may be on a limited edge. Try moving one or more stops with the Network Position Select / Move Tool (Select / Move Network Locations Tool) located on the Network Analyst toolbar.

1. Click the Directions Window button Network Analyst toolbar.

The Directions dialog box opens (Figure 1.79).

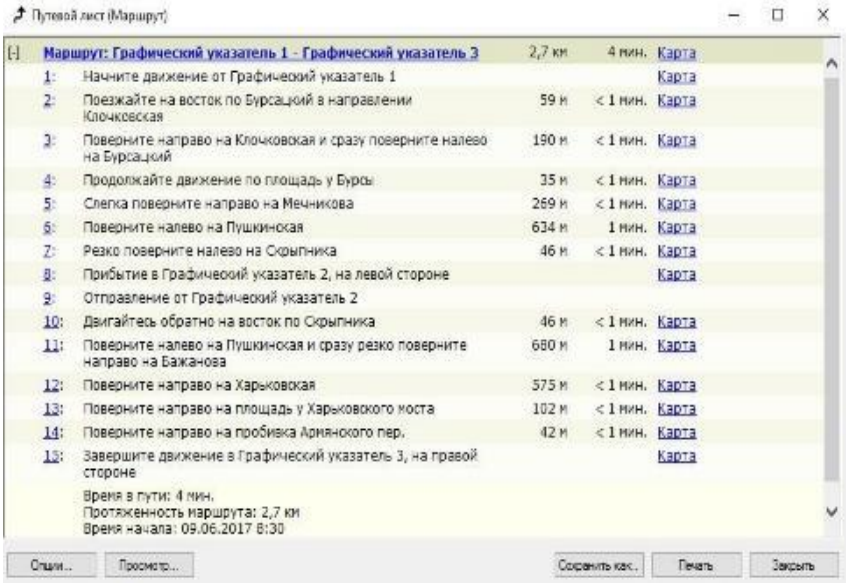


Figure 1.79

2. Click Close.

Adding a barrier

To depict an obstacle and find an alternate route to the destination on the route you need to add a barrier.

Steps:

1. Click Windows> Magnifier. The Magnifier window opens.

2. Click on the title of the Magnifier window and move it to be located above the route (Fig. 1.80).

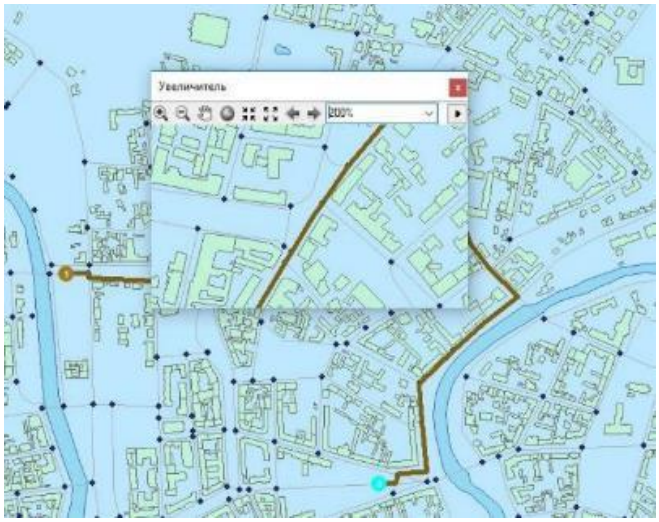


Figure 1.80

3. In the Network Analyst window in the Point Barriers area (0) click Restriction (0).

4. Click the Create Network Position tool (Create Network Location) Network Analyst toolbar.

5. In the Magnifier window, click anywhere on the route to place one or more barriers (Figure 1.81).

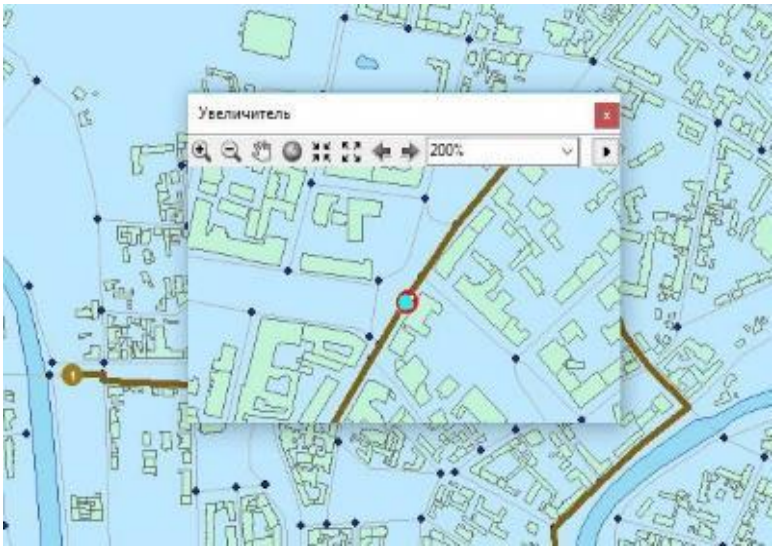


Figure 1.81

6. Click the Solve button Network Analyst toolbar.

We get an alternative route designed to bypass the barrier (Fig. 1.82).

Figure 1.82

7. Close the Magnifier window.

Save the route

The route analysis layer is stored in memory, and if you get out of ArcMap without saving, the analysis will be lost. However, if you save the map document, the analysis layer will be saved with it. You can also export data. One way is to export the network analysis layer to a LYR file. Analysis properties and objects are stored in a LYR file. Another way is to preserve the analysis sublayers as object classes using the Export Data command. The following shows how to export sublayers of routes to a feature class.

Steps:

1. In the Network Analyst window, right-click Routes (1) and select Export Data (Fig. 1.83).

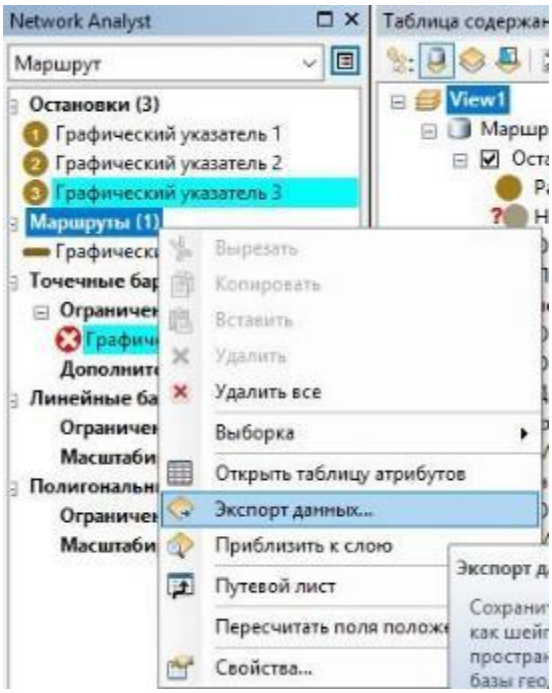


Figure 1.83

The Export Data dialog box opens.

2. In the Output feature class text box, enter or specify a location to save the results, such as C: \ ArcGIS \ ArcTutor \ Network Analyst \ Tutorial \ Kharkiv.gdb \ Exercise3_Route.

3. Click OK. The route object will be saved in the specified workspace.

4. Click No to add the exported data to the map as a layer.

If you do not need to work with other exercises, close the ArcMap application. Click No to save the changes.

If you want to continue working with other exercises, you need to do the following:

a) click on File> New. A dialog box opens New Document;

b) click OK;

c) Click No in response to the request to save changes.

The task of constructing the shortest route from the starting and intermediate points in the city of Kharkiv has been solved.

1.4 Analysis of the road network graph

Ensuring the stable functioning of passenger transport systems can be considered a priority for transport organizers and carriers. Under certain conditions, providing passengers with the opportunity to meet the needs of movement in the most convenient way is the basis for the maximum realization of potential transport correspondence between the nodes of the transport network. The main factors influencing the actual indicators of passenger traffic between the nodes of the transport network can be considered: potential correspondence, fare, travel time, time of day, ride comfort, regularity and frequency of travel, social and economic characteristics of population development in transport hubs. note that the actual indicators of passenger traffic should be adjusted according to seasonal or daily fluctuations.

For its part, the long-distance passenger route transport system uses financial resources from transportation to support its activities. The planned inflow of money is undoubtedly important for ensuring the stable operation and development of long-

distance passenger route transport systems. It is equally important to properly distribute cash flows between elements of the transport system in time and quantity. Balanced movement of financial flows within the system, the quantitative sufficiency of this resource and its reasonable use of elements of the system is possible planning and development of the industry as a whole.

The object of study of this section is the state transport network of Ukraine. Consider the existing network of roads that form a modern transport network. The considered road network consists of more than 70 thousand arches and nodes, which describe the routes of interregional, regional, international and regional importance. This made it possible to determine the options for the shortest connection of network nodes.

One of the most problematic issues is to improve the quality of transport parameters. Scholars have mostly considered the optimization of traffic schedules, the choice of rolling stock and determining the optimal routes. Transport networks are part of transport systems and provide the ability to transport goods and passengers between nodes. At the same time, the peculiarities of the transport network affect the general performance of the transport process, namely: the density and intersvity of the flow of vehicles, the speed of communication, the length of the ride.

At the present stage of research to determine the parameters of the functioning of transport, many different approaches have been proposed [1]. In [2] it was found that the availability of passenger transport correspondence significantly affects the state of social and economic development of society. The dependence of transport correspondence on routes on social components is described mathematically. In work [3] the system of long-distance passenger transport is modeled. In these works, the driving distance Lij between points i and j is a factor of resistance to the realization of potential correspondence between cities i and j (Hij).

The author of [4] considers the factors influencing the formation of the cost of rail freight. It is established that the length of the freight ride is directly proportional to the increase in transportation costs. The work [5] is devoted to the determination of the cost and cost of railway transportation, in which the author proves the need to reduce

the length of technological races of cars and the current composition to reduce the cost of both passenger and freight.

In [6], the authors provide a definition according to which the transport infrastructure is a transport network consisting of nodes and arcs. In [7] it is established that the model of the transport network aims to describe transport communications (highways and railways, water and air routes) in the form of a connected graph. In addition, it is determined that the route network consists of nodes and arcs, and sometimes contains routes. Based on these conclusions, the authors of [7] propose to describe nodes by points and arcs by polylines and implement such models using geographic information systems. In [8] the method of solving the problem of modeling transport processes is presented, which, in particular, is based on the theory of graphs applied to road networks. As nodes, the authors consider the intersection, end and beginning of arcs (streets),

In [9], the authors propose to analyze transport networks using geographic information technologies. The authors of [10] were interested in the results of consideration of modern information systems used in engineering networks. In their opinion, among the proposed modern systems, the most optimal for use in the consideration of engineering measures are automated design systems and geographic information systems. Geographic information systems in the analysis of transport networks are used by the authors of [11]. The author considers it necessary to combine mathematical methods of graph analysis by building geographic information systems in the process of planning transport networks and traffic management. The paper [12] considers the use of geographic information systems to solve the problems of transport in the region. The author of [13] investigated, how the development of the transport network affects the economic development of the region, and in [14] the issue of assessing the impact of transport infrastructure on the socio-economic development of the region is considered. In [15] the expediency of realization of mathematical methods of graph reduction by GIS applications during planning of transport networks is proved. In [16–19], the authors use GIS tools to estimate the image of the city's route network, determining the total length of the network in square kilometers.

This section shows how you can automatically determine the center and diameter of a graph built with Network Analyst, namely:

1. Activate the ArcGIS Network Analyst plug-in by following these steps:

a) clickon Settings(Customize)> Additionalmodules (Extensions). The Extensions dialog box opens;

b) mark ArcGIS Network Analyst;

c) click Close.

If the Network Analyst toolbar doesn't appear, you'll need to add it.

2. Click Customize> Toolbars> Network Analyst.

The Network Analyst toolbar will be added to ArcMap (Figure 1.84).

Figure 1.84

If the Network Analyst window does not appear, you need to add it.

3. On the Network Analyst toolbar, click the Window button

Network Analyst (Network Analyst window). The attached Network Analyst window will open (Fig. 1.85).

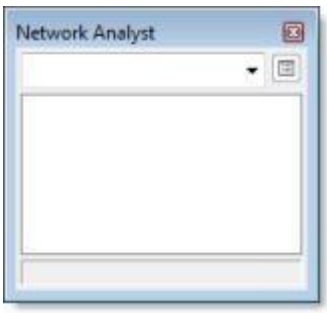


Figure 1.85

The Network Analyst window can be pinned and unpinned.

Creating a layer of analysis of the source-destination matrix

You need to create a Source-Destination matrix to determine the center and diameter of the graph. This matrix can be used to determine the shortest distances between all pairs of vertices, the sum of the shortest distances from one vertex to all other vertices, and the center and diameter of the graph.

Steps:

Click Network Analyst on the Network Analyst toolbar and the New OD Cost Matrix (Fig. 1.86).

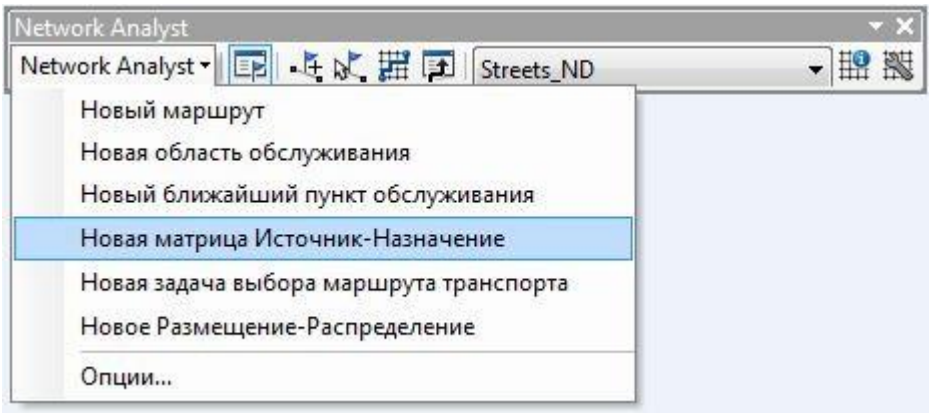


Figure 1.86

The Source-Destination matrix analysis layer has been added to the Network window

Analyst Network analysis classes: Origins, Endpoints (Destinations), Lines, Point Barriers, Line Barriers and Polygon Barriers are empty (Fig. 1.87).

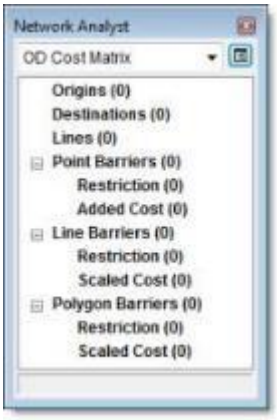


Figure 1.87

Also in the Table of Contents window a new layer of analysis will be added (Fig. 1.88).

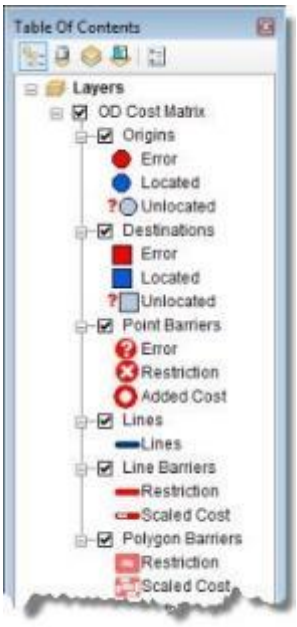


Figure 1.88

Adding origins

Steps:

1. In the Network Analyst window, right-click Origins (0) and select Load Locations.

The Load Locations dialog box opens (Fig. 1.89).

2. Click Center in the Load From list.
3. Click the Only load selected rows check box.
4. In the Location Position section, click Use Geometry (Figure 1.89).

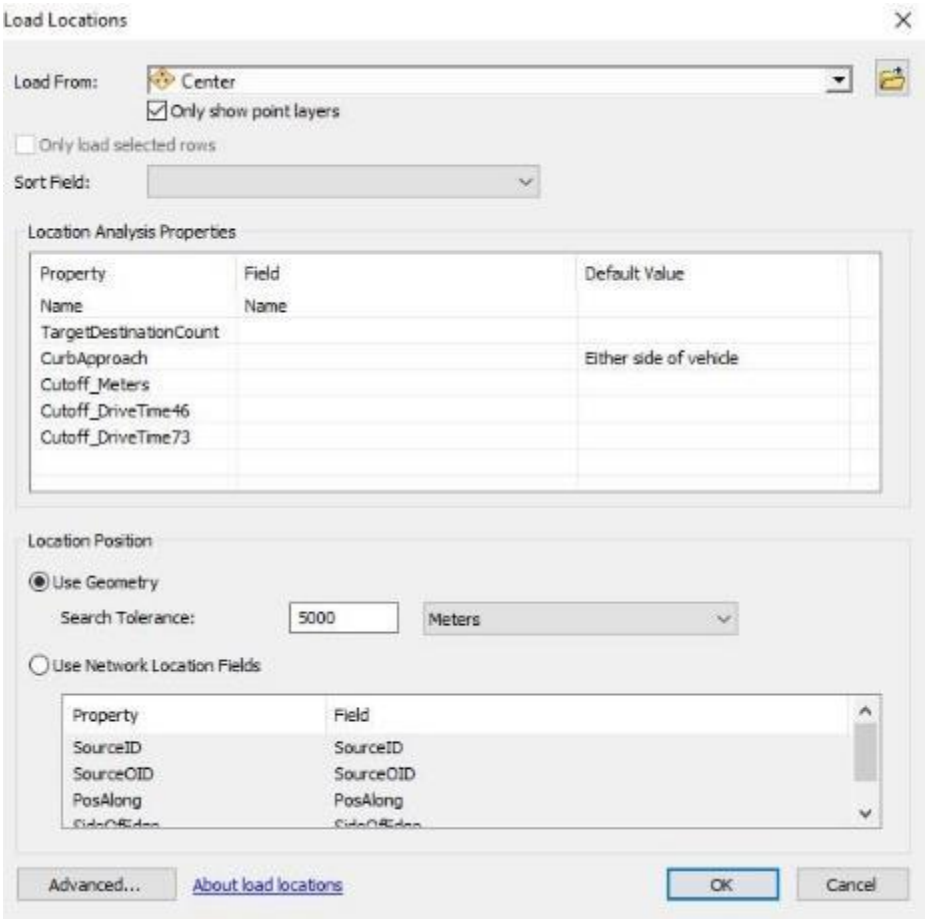


Figure 1.89

5. Click OK.

The use of geometry fields allows ArcGIS to use an already located service area position to redefine them as a source. This method allows you to redefine your location much faster than you can with spatial search. 25 new objects will be displayed in the Network Analyst window in the Origins section.

Add appointments

Steps:

1. In the Network Analyst window, right-click the Destination button (Destinations (0)) and choose team Load Locations.

2. Click Center in the Load From list.

3. Click the Only load selected rows check box.

4. In the Location Position section, click Use Geometry (Figure 1.90).

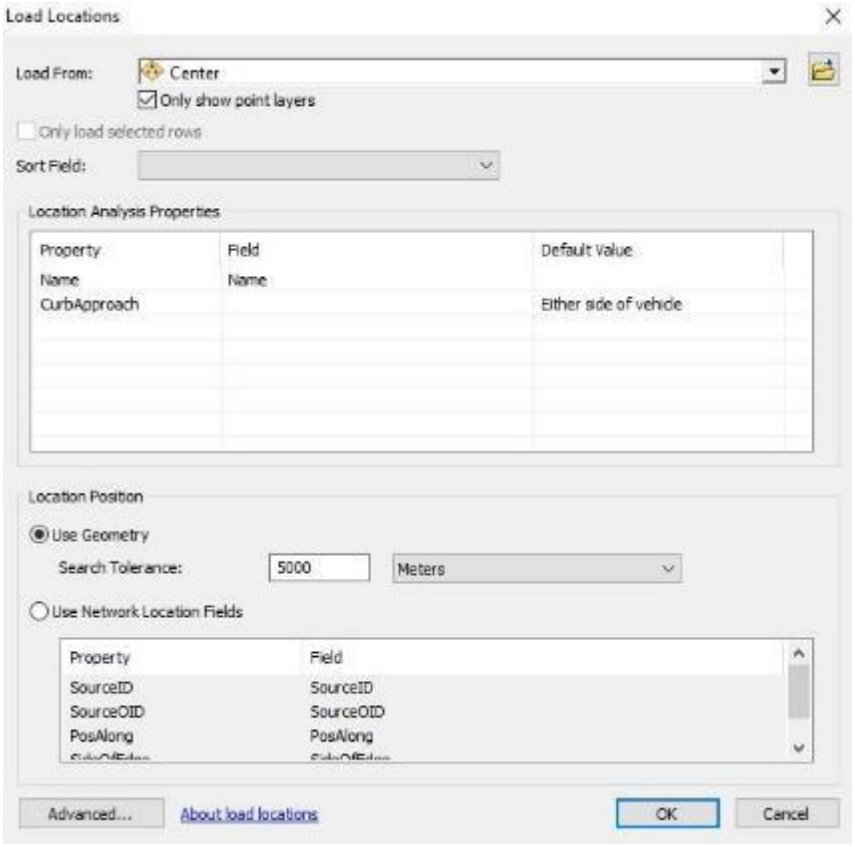


Figure 1.90

5. Click OK.

The Network Analyst window will contain 25 objects from the list of destinations (Fig. 1.91).

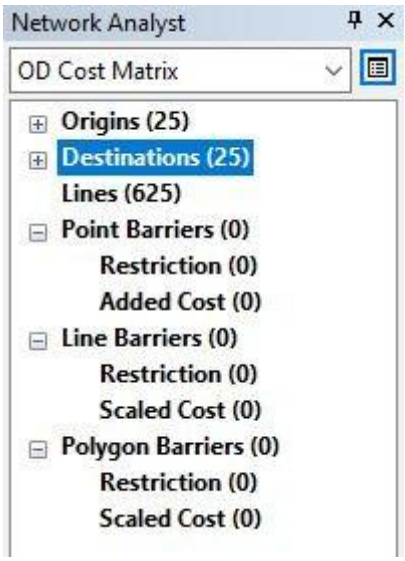


Figure 1.91

These values will be displayed on the map (Fig. 1.92).

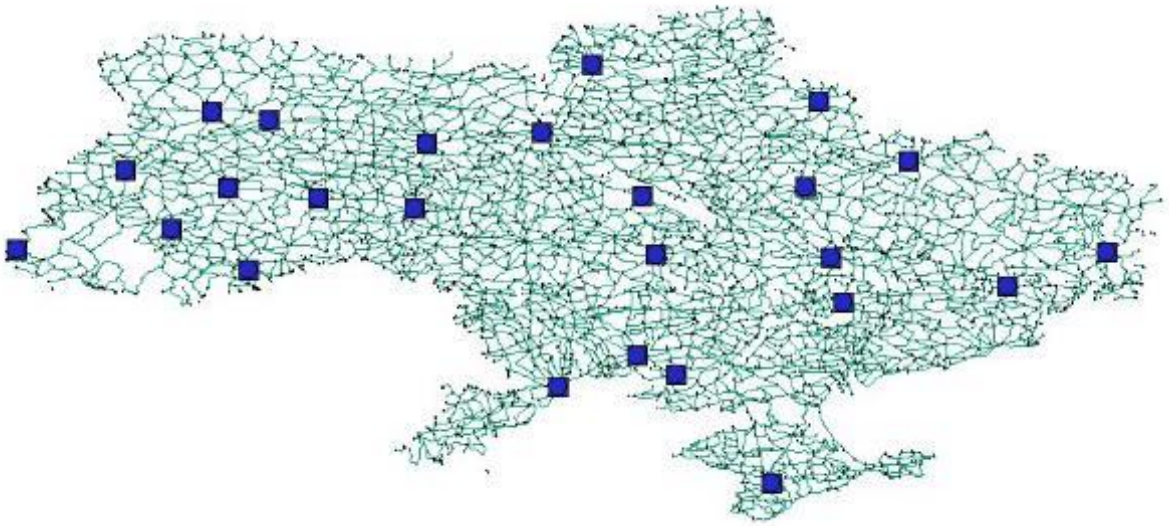


Figure 1.92

Figure 1.92 shows a model of the transport network of Ukraine, which contains not only nodes and arcs, but also visualizes cities of regional importance.

Start the process of creating a source-destination matrix

In the next step, we calculate the Source-Destination matrix by choosing the shortest distance between all pairs of vertices. As the route is on the road, it should be borne in mind that all incorrect locations (location not found) are ignored.

Steps:

1. Click the Solve button Network Analyst toolbar.
2. Source-Destination lines will be displayed on the map. In this example, it is 625 lines (Fig. 1.93).

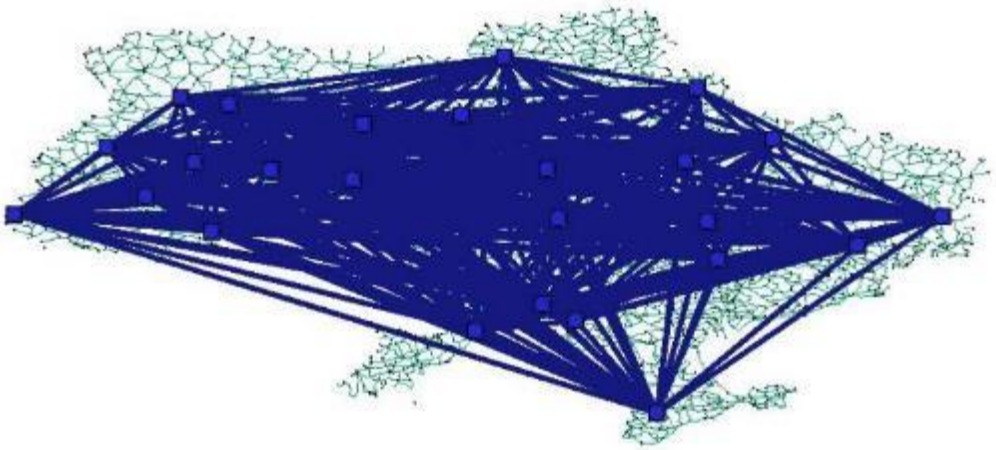


Figure 1.93

Calculated matrix Source-Purpose, having chosen the shortest distance between all pairs of vertices is calculated.

Determination of the diameter of the graph

In the Network Analyst window, right-click on Lines (625) and select Open Attribute Table (Figure 1.94).

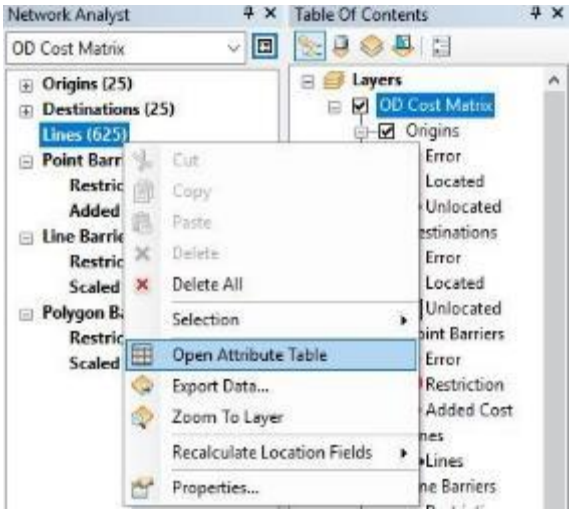


Figure 1.94

The Lines table opens (Fig. 1.95).

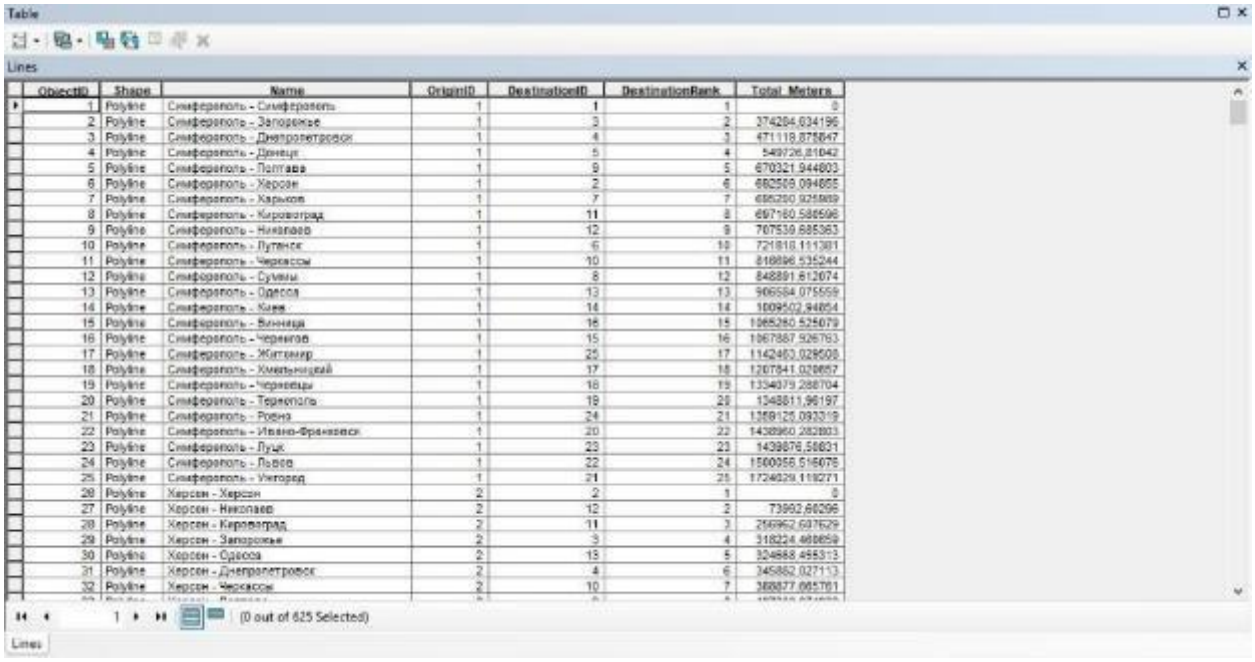


Figure 1.95

The Lines table is a Source-Destination matrix.

To find the diameter of the graph, you need to sort and determine the maximum distance (Total_Meters column) from one regional center to another.

Steps:

1. Right-click on the name of the column Total_Meters and select the sorting method from largest to smallest (Fig. 1.96).

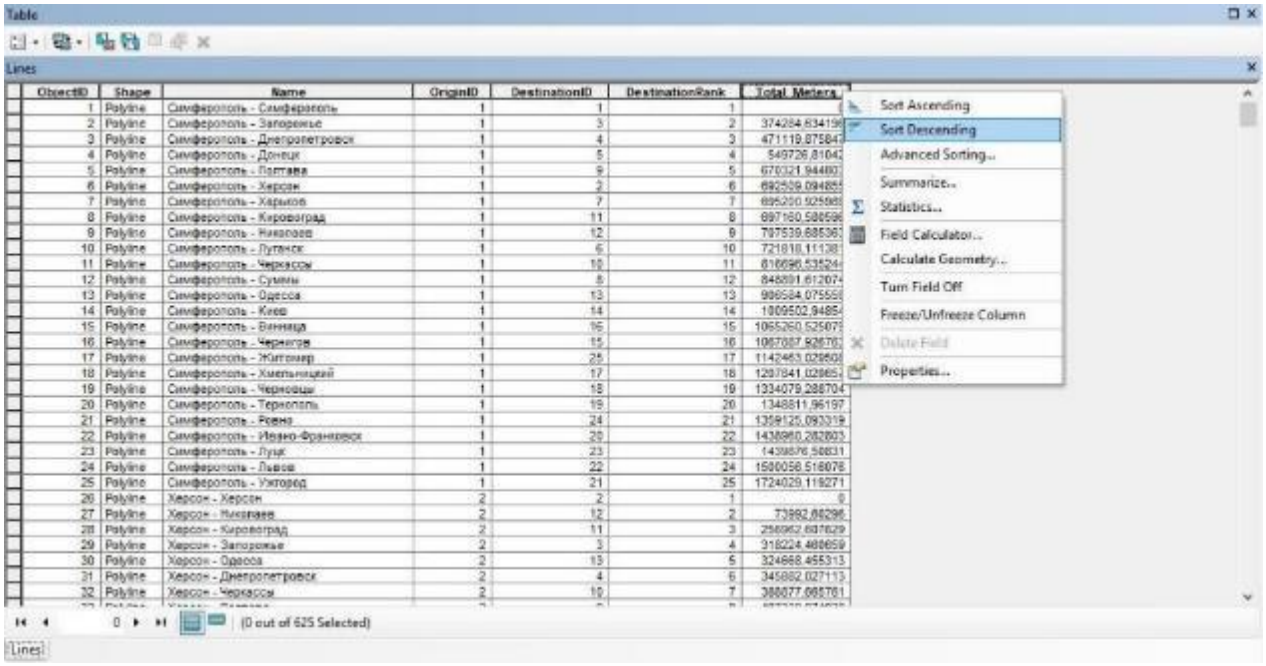


Figure 1.96

After sorting, the two distances between regional centers will be the same (Fig. 1.97).

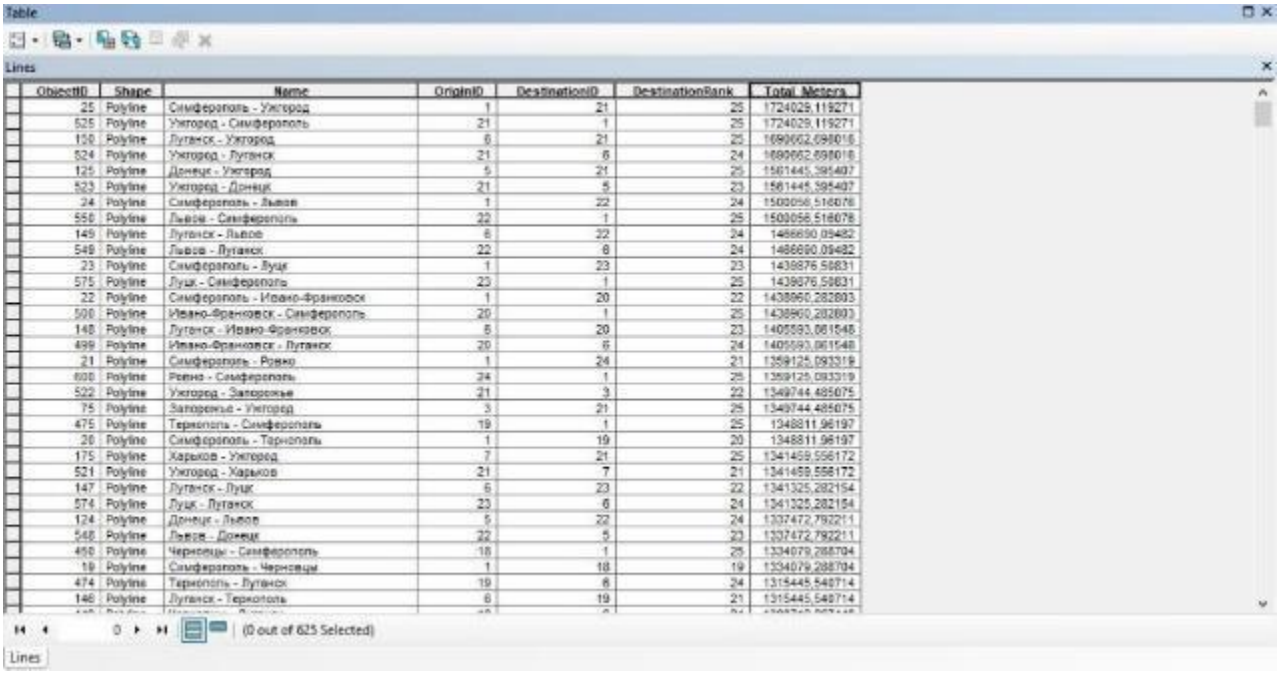


Figure 1.97

2. Close the table.

3. Find these distances in the vertex table. To do this, you need to open the table of regional centers.

4. In the Network Analyst window, right-click Center and select Open Attribute Table (Fig. 1.98).

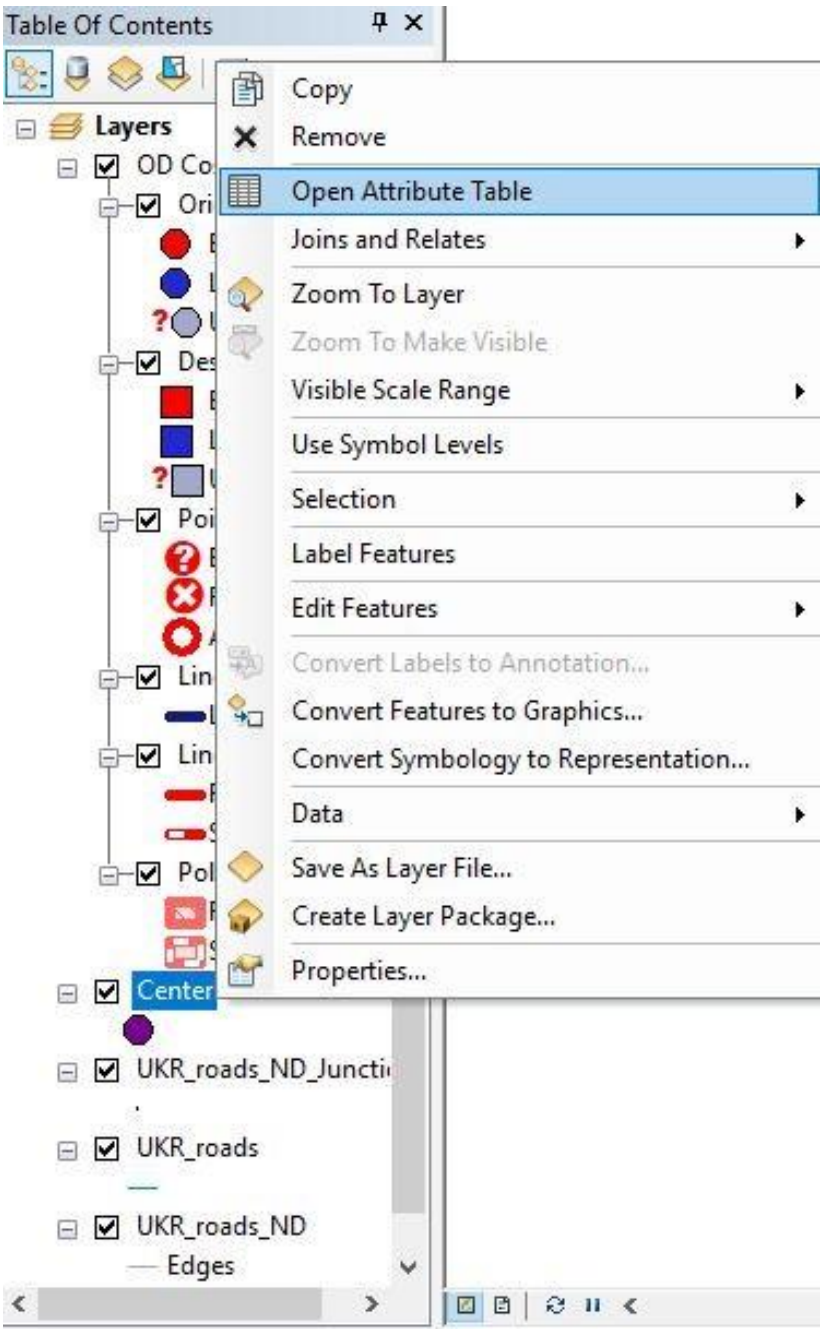


Figure 1.98

The table of attributes of the regional centers opens (fig. 1.99).

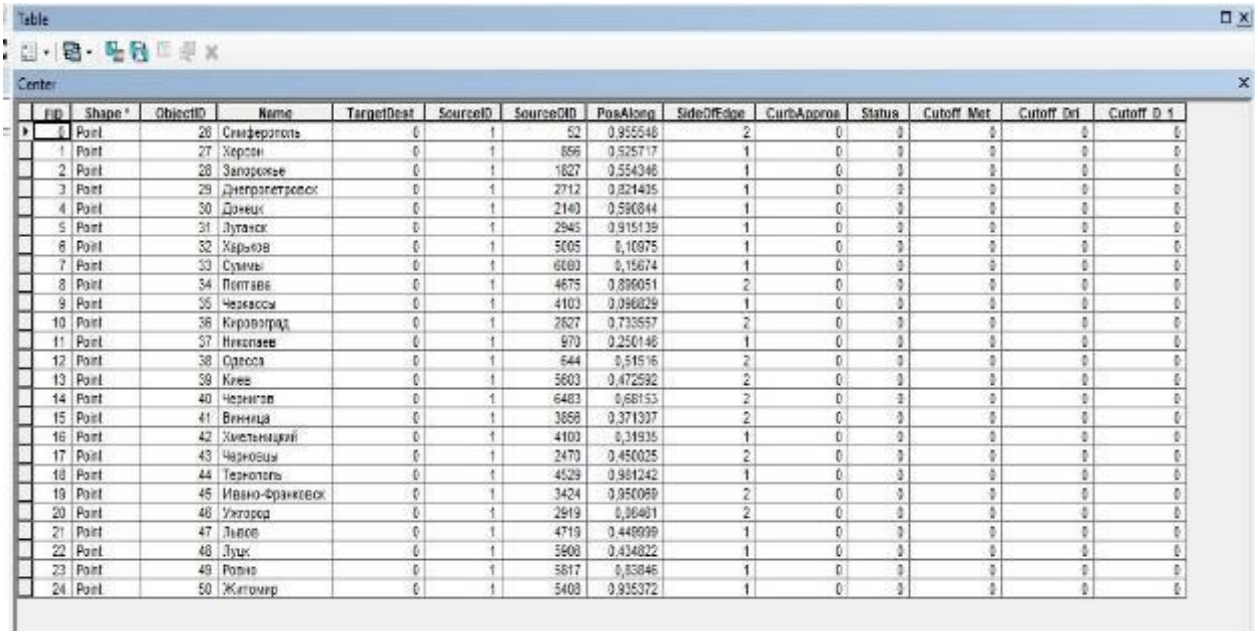


Figure 1.99

5. It is necessary to distinguish two regional centers - Simferopol and Uzhgorod, as the distance between them is the largest (Fig. 1,100).

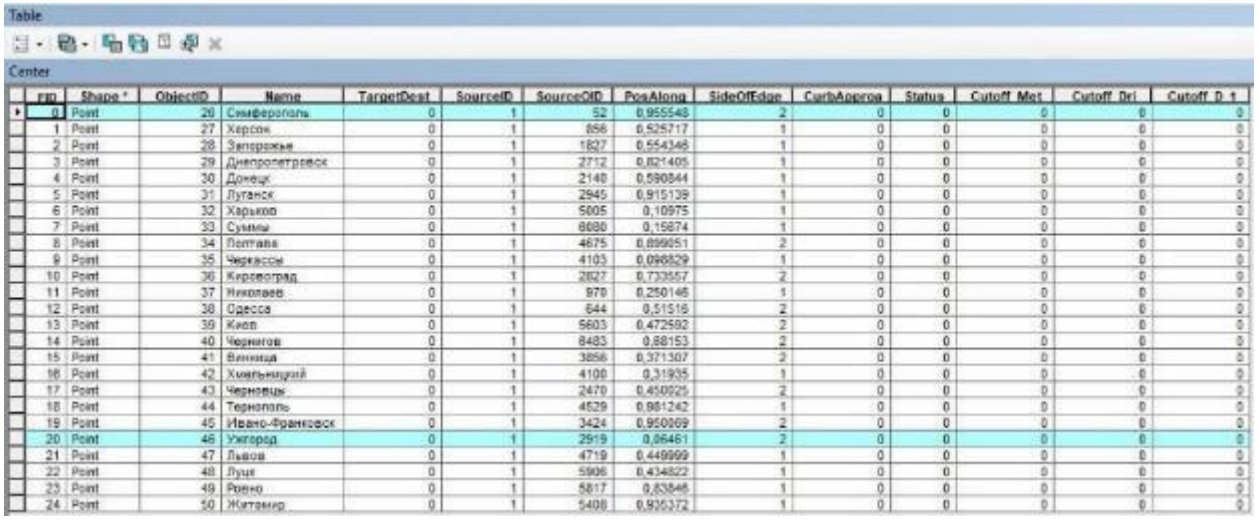


Figure 1.100

6. Close the table.

Two vertices are marked on the map, they are considered the most distant centers (Fig. 1.101).

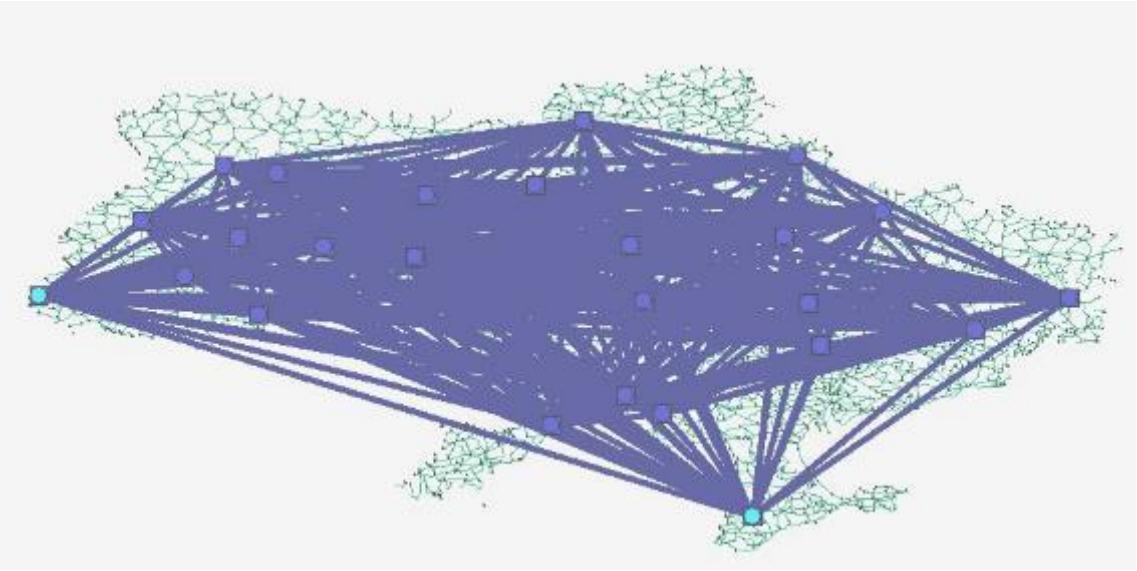


Figure 1.101

7. Unlock the OD Cost Matrix in the Table Of Contents window to improve the visibility of regional centers (Figs. 1.102, 1.103).

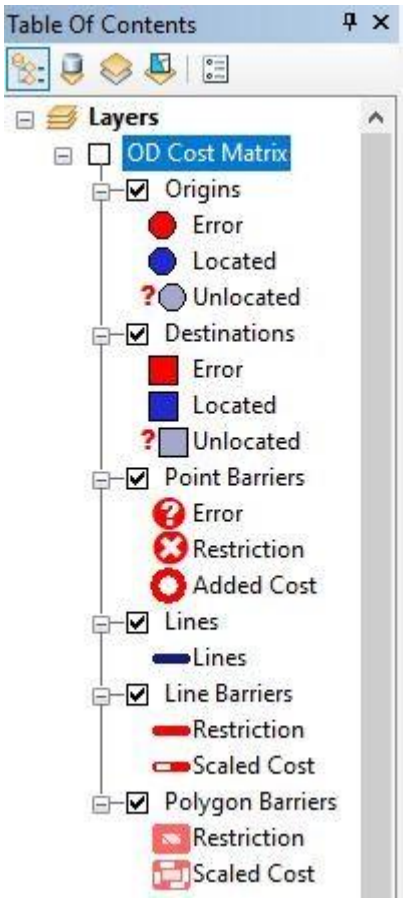


Figure 1.102

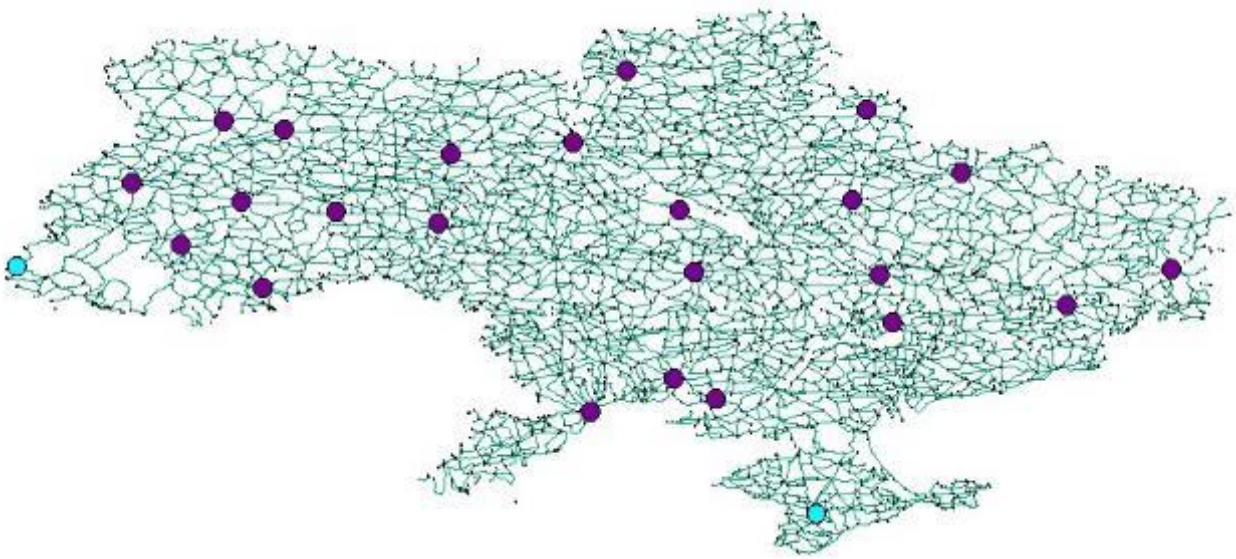


Figure 1.103

Draw a route and determine the diameter of the graph.

Create a route layer

Click Network Analyst on the Network Analyst toolbar and New Route (Figure 1.104).

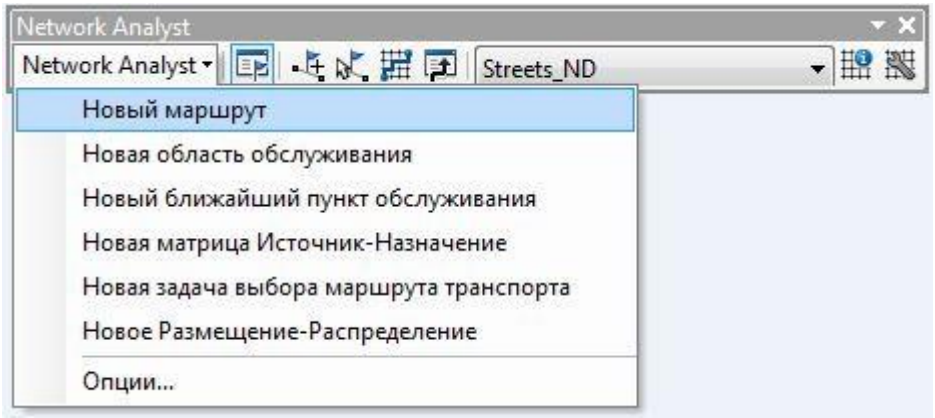


Figure 1.104

The route analysis layer will be added to the Network Analyst window. Classes of network analysis: Stops, Routes, Point Barriers, Line Barriers and Polygon Barriers are empty (Fig. 1.105).

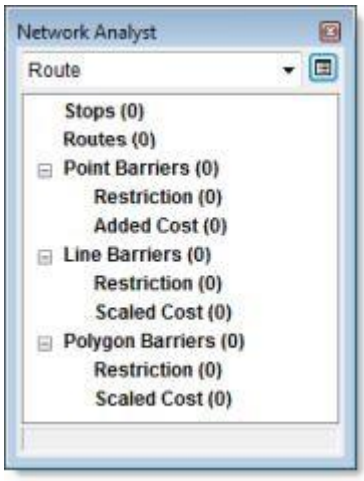


Figure 1.105

A new layer of analysis will be added to the Table Of Contents window (Fig. 1.106).

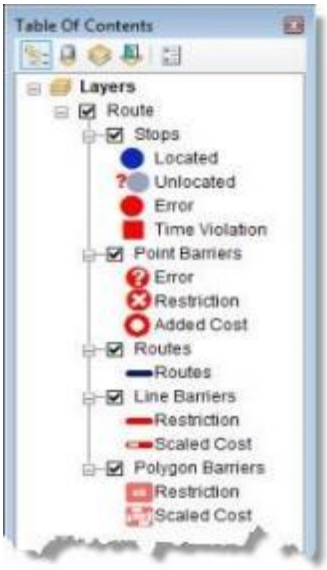


Figure 1.106

Add a stop

Then you need to add the necessary stops of the route Steps:

1. In the Network Analyst window, click Stops (0).

Selecting a stop means that it is in the active network analysis class.

2. On the panel tools Network Analyst click on the map Create Network Location Tool .

By clicking on the Create Network Location Tool, you can add network analysis objects to the active network analysis class.

3. Click on the two regional centers that are marked on the map of the street network to determine the location of the stop (Fig. 1.107).

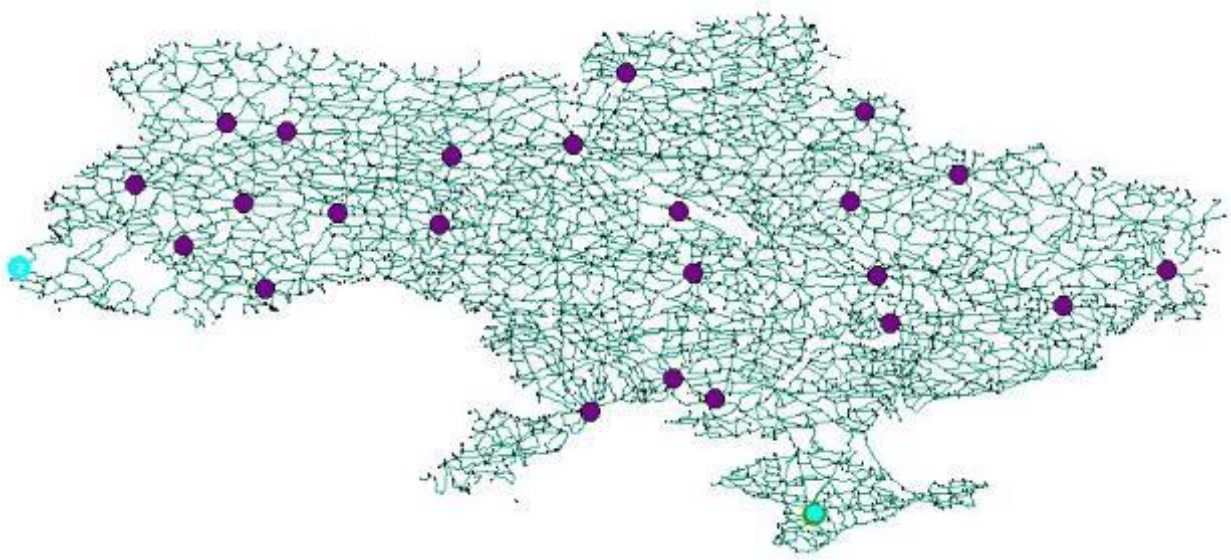


Figure 1.107

Network Analyst calculates the nearest network location and marks the stop with the Located symbol. The stop remains selected until another stop is placed or the selection is canceled.

The located stop displays the number 1. All stops are marked with unique numbers that make up the order in which the stops are located along the route. It should be noted that in the list of the Stops class in the Network Analyst window, one stop is currently specified (Fig. 1.108).

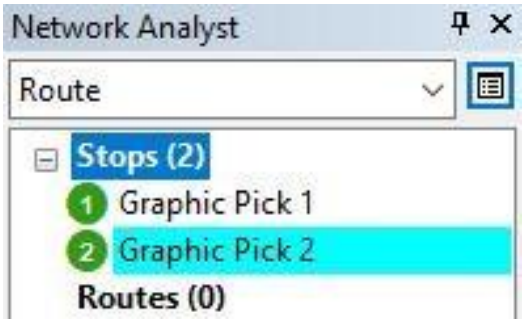


Figure 1.108

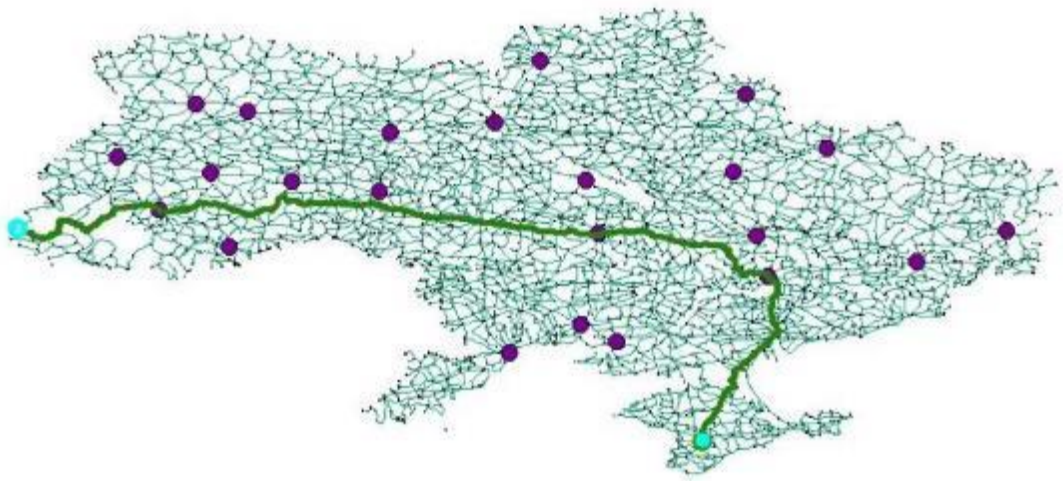


Figure 1.109

The first stop is considered the starting point, and the last - the destination.

4. Click the Solve button on the Network Analyst toolbar.

The route object will appear in the map document and in the ArcGIS Network Analyst window under the Routes class.

5. Close the warning window (Fig. 1.109).

Determination of the topological center of the graph

You must first return to the matrix layer and open the Lines attribute table.

Steps:

1. Select the OD Cost Matrix in the Network Analyst window (Fig. 1.110).

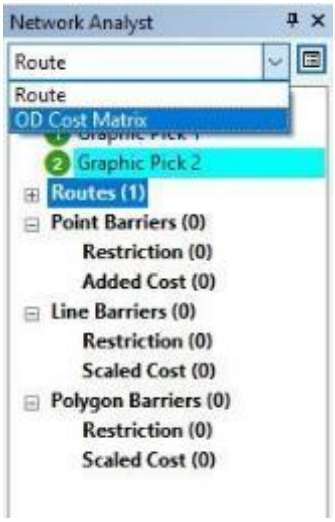


Figure 1.110

2. In the Network Analyst window, right-click Lines (625) and select Open Attribute Table (Fig. 1.111).

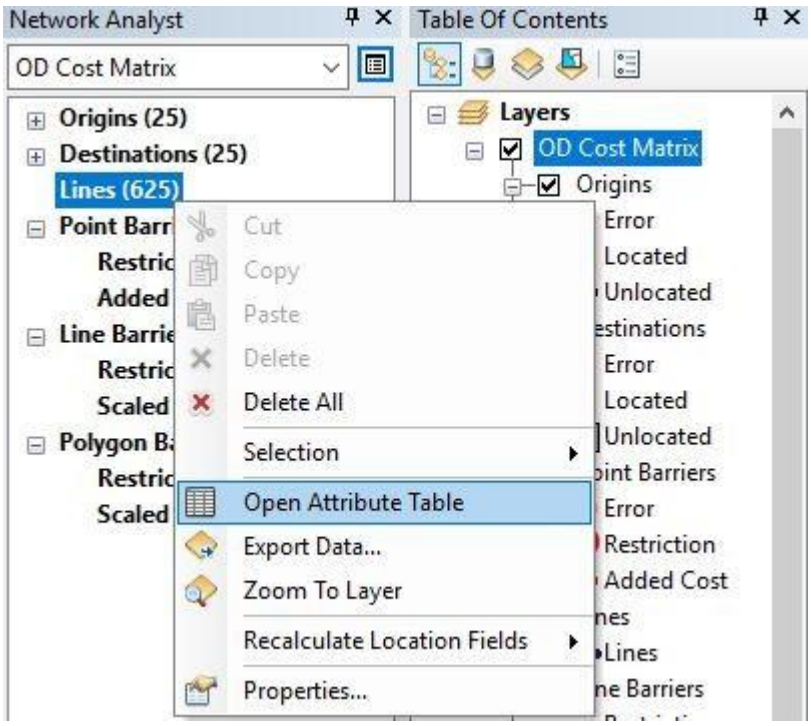


Figure 1.111

The Lines table opens (Fig. 1.112).

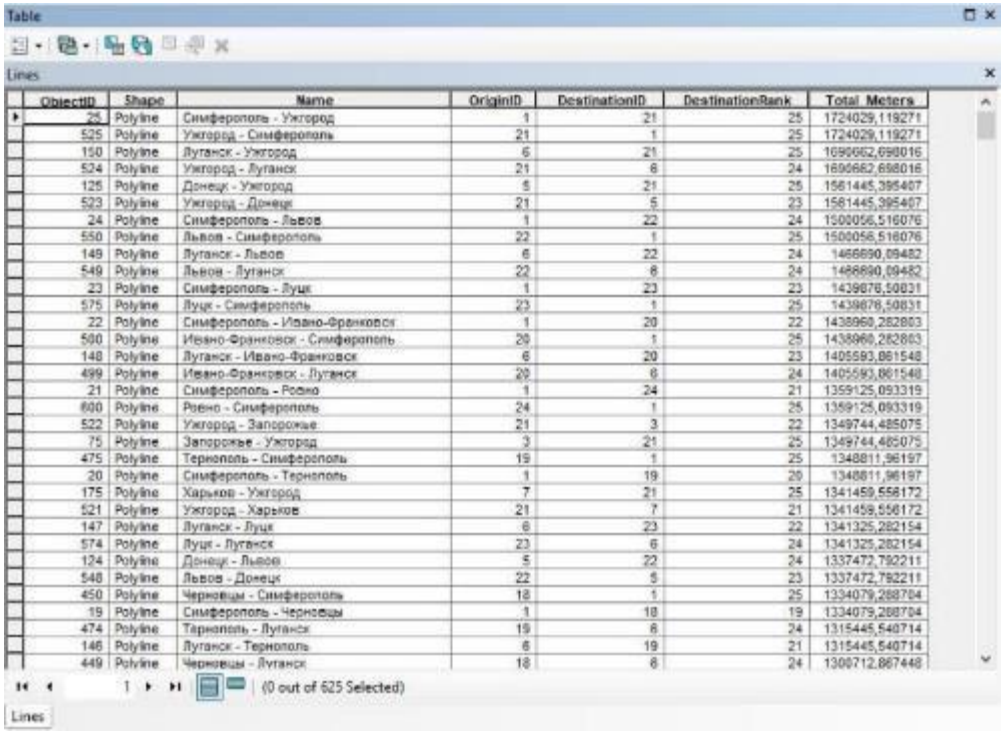


Figure 1.112

It is necessary to find the center to which the sum of the shortest distances from other centers is minimal. To do this, sort the table by OriginID and DestinationID.

3. Right-click on the Name column and select Advanced Shorting (Figure 1.113).

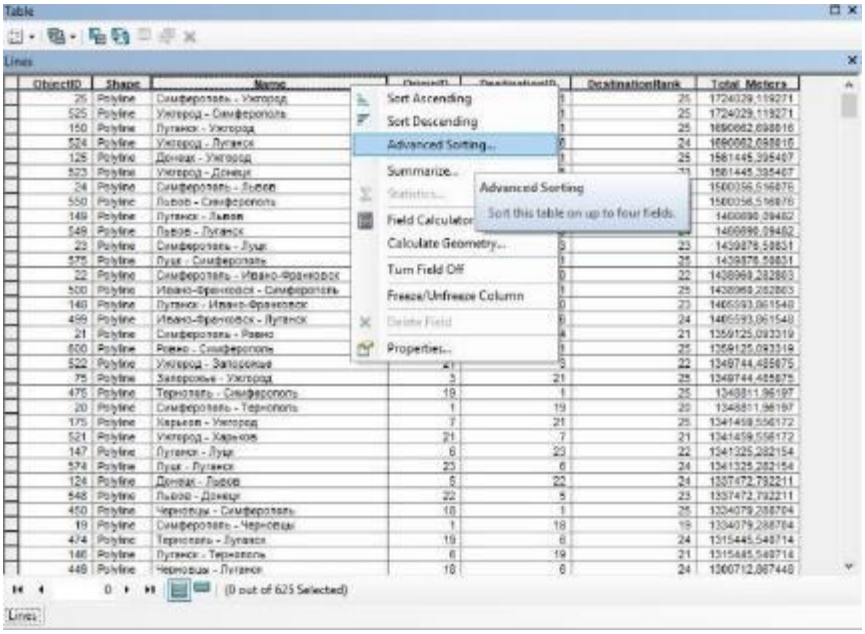


Figure 1.113

The sorting table opens (Fig. 1.114).

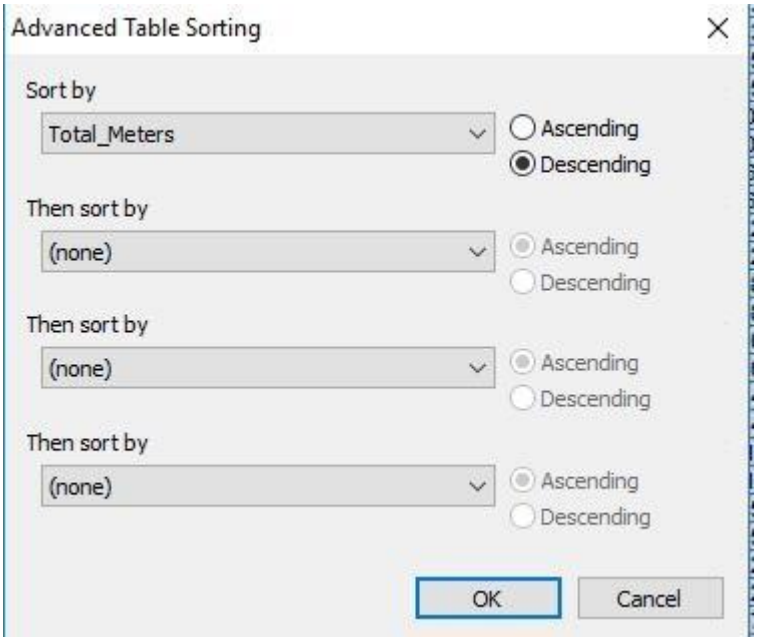


Figure 1.114

4. Select the OriginID column in the Short by row, and change the value of Descending to Ascending. In the line Then sort by select DestinationID (Fig. 1.115).

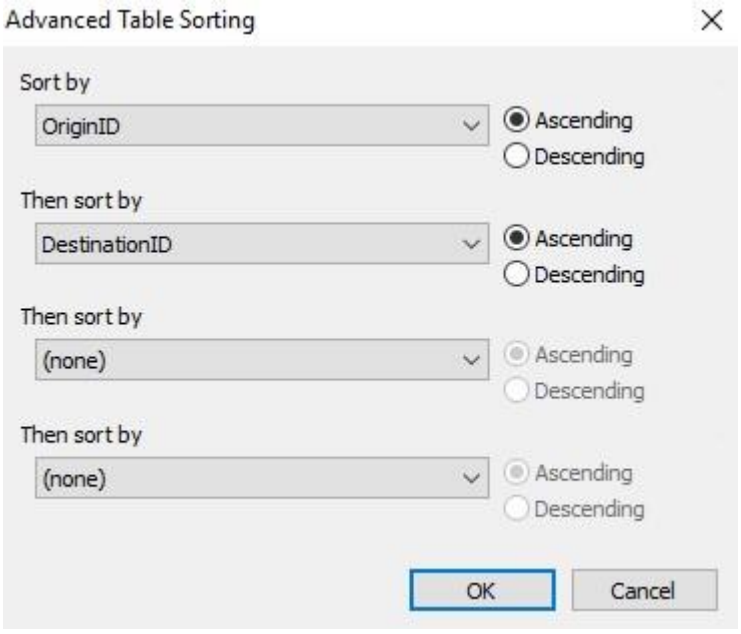


Figure 1.115

Thus, the table is sorted by OriginID and DestinationID columns (Fig. 1.116).

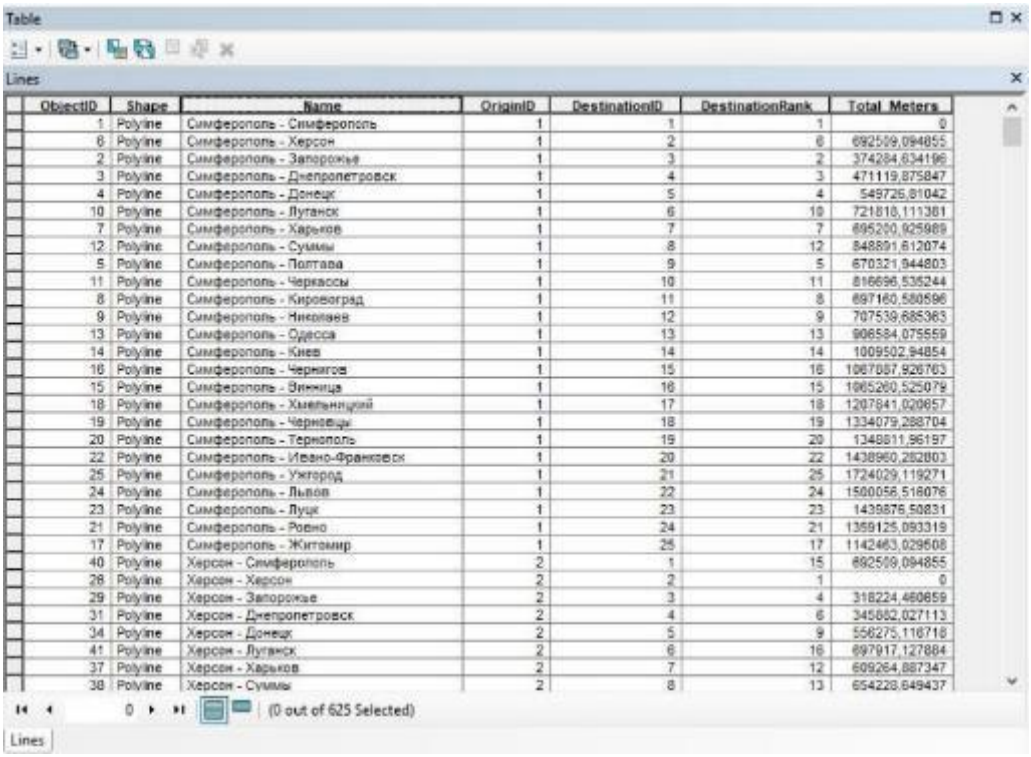


Figure 1.116

5. Use the Dissolve command to add the entire distance.

Click the Geoprocessing button on the ArcMap main panel and select Dissolve. The Dissolve window opens (Fig. 1.117).

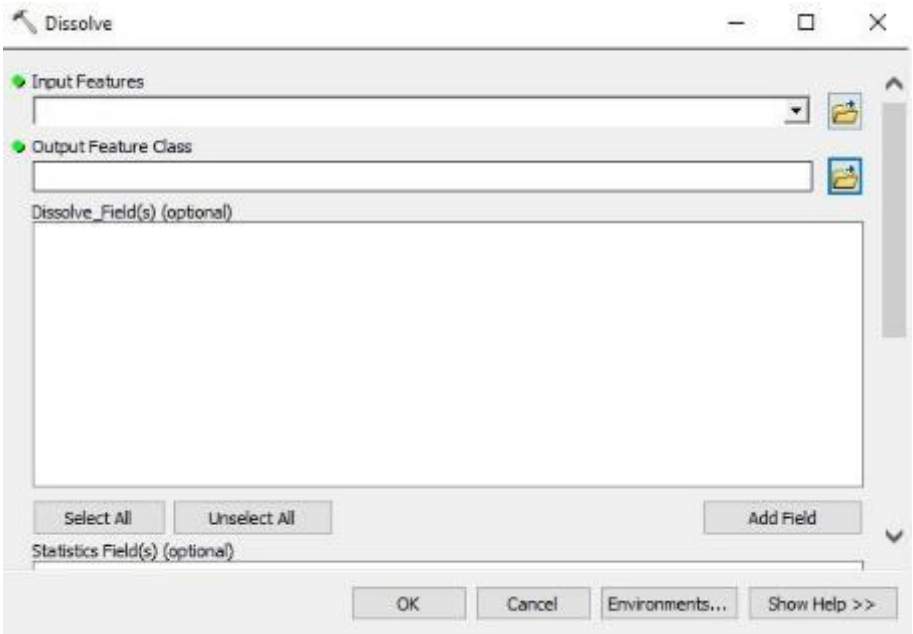


Figure 1.117

6. In the Input Features field, select Lines, and then in the Dissolve_Field (s) window, select OriginID.

7. Select Total_Meters in the Statistics Field and Sum in the Statisic Type column.

The Output Feature Class field is responsible for storing the topological center of the graph. The topological center of the graph is stored under the name ODLines_Dissolve. The Dissolve window should look like this (Fig. 1.118):

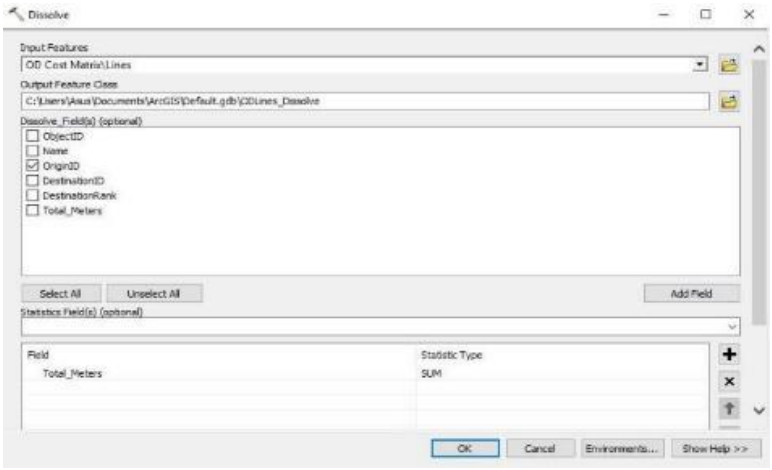


Figure 1.118

8. Click OK.

9. A new layer called ODLines_Dissolve has been added to the Table Of Contents window.

In the Table Of Contents window, click a new layer ODLines_Dissolve and select the Attribute Table command (Fig. 1.119).

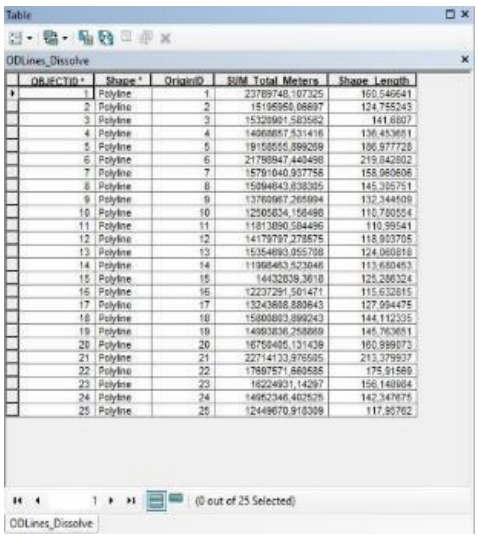


Figure 1.119

10. Next, you need to find the minimum amount on the attribute table.

Right-click on the column name SUM_Totatl_Meters and select sort from smallest to largest (Sort Ascending) (Fig. 1.120).

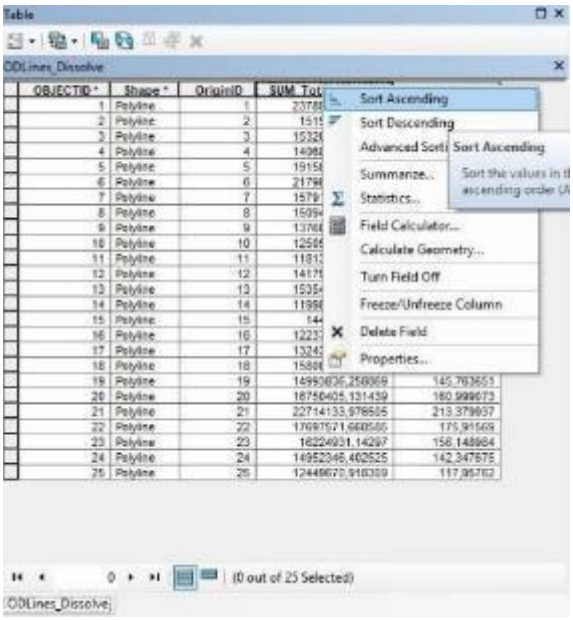


Figure 1.120

The sums of distances of regional centers from the minimum to the maximum are sorted.

11. Select the first line (Fig. 1.121).

Table

ODLines_Dissolve

OBJECTID *	Shape *	OriginID	SUM_Total_Meters	Shape_Length
11	Polyline	11	11813890,584496	110,99541
14	Polyline	14	11998463,523046	113,680453
16	Polyline	16	12237291,501471	115,632815
25	Polyline	25	12449670,918309	117,95762
10	Polyline	10	12505834,156498	110,780554
17	Polyline	17	13243608,880643	127,994475
9	Polyline	9	13760967,265994	132,344509
4	Polyline	4	14068657,531416	136,453651
12	Polyline	12	14179797,278575	118,903705
15	Polyline	15	14432839,3618	125,286324
24	Polyline	24	14952346,402525	142,347675
19	Polyline	19	14993836,258869	145,763651
8	Polyline	8	15094643,638305	145,305751
2	Polyline	2	15195950,06697	124,755243
3	Polyline	3	15320901,583562	141,6807
13	Polyline	13	15354693,055708	124,060818
7	Polyline	7	15791040,937756	158,960606
18	Polyline	18	15800803,899243	144,112335
23	Polyline	23	16224931,14297	156,148984
20	Polyline	20	16750405,131439	160,999073
22	Polyline	22	17697571,660585	175,91569
5	Polyline	5	19158555,899269	186,977728
6	Polyline	6	21798947,440498	219,842802
21	Polyline	21	22714133,976505	213,379937
1	Polyline	1	23789748,107325	160,546641

Figure 1.121

12. Close the table.

The defined regional center is the topological center of the graph (Fig. 1.122).

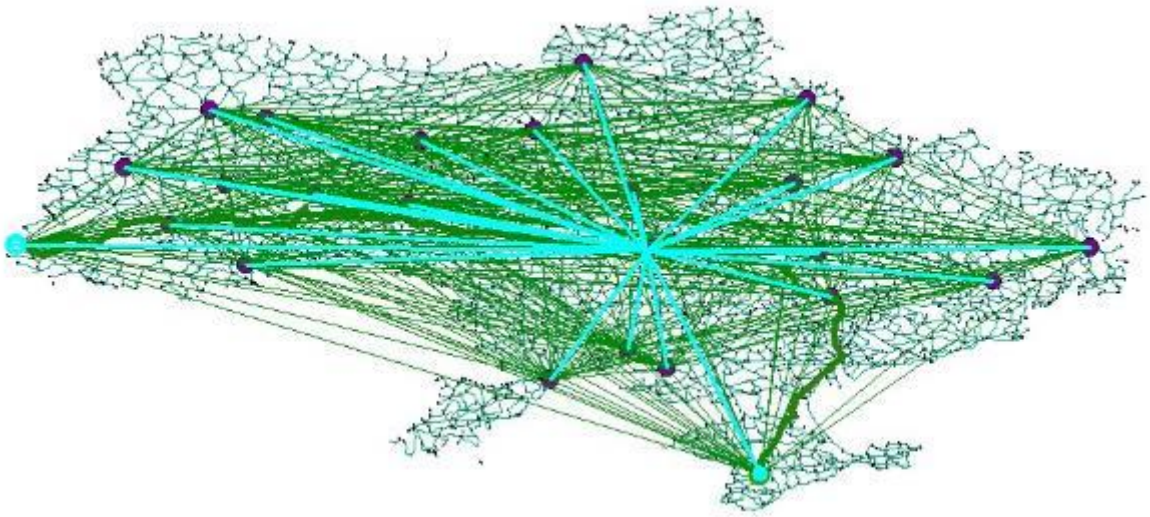


Figure 1.122

If you do not want to continue, close the ArcMap application.

Click No to save the changes.

2 SIMULATION OF TRANSPORT TASKS

2.1 Modeling of optimal trajectories between network objects

Route modeling is one of the main tasks of transport. Such tasks are solved if, for example, you need to choose a store to meet household needs. At the subconscious level, each of us chooses a store that not only meets the conditions of the possible realization of the need to make purchases, but also is located in the most convenient place. The requirements for such a location are remoteness and travel time [20-24].

Similar needs for planning similar tasks are observed when identifying facilities for assistance that are located in the most advantageous places. The needs of the population to travel by taxi are also met by solving similar problems.

This section offers a sequence of actions in ArcMap software. The aim is to identify objects located in the network that meet the requirements of users. Such requirements are the proximity of objects and the estimated travel time to them in the network. The result of this work were models of the proposed routes from the user to the objects, built taking into account the constraints. To ensure such modeling, the road network of Kharkiv was used [25–29].

Steps:

1. Start ArcMap, select Start> All Programs> ArcGIS> ArcMap 10.5.

2. In the ArcMap dialog box Getting Started (ArcMap – Getting Started) click on Existing Maps> Browse for more.

The Open ArcMap Document dialog box appears.

3. Navigate to the folder with the file - network data set of Kharkiv.

4. Activate the ArcGIS Network Analyst plug-in by following these steps:

a) click on Settings (Customize)> Additional modules (Extensions). The Extensions dialog box opens;

b) mark ArcGIS Network Analyst;

c) click Close.

If the Network Analyst toolbar doesn't appear, you'll need to add it by clicking Customize> Toolbars> Network Analyst.

The Network Analyst toolbar will be added to ArcMap (Figure 2.1).

Figure 2.1

If the Network Analyst window does not appear, you need to add it. On the Network Analyst toolbar, click the Network Analyst window.

The attached Network Analyst window will open (Fig. 2.2).

Figure 2.2

The Network Analyst window can be pinned and unpinned.

Create a layer of the nearest service point

Click Network Analyst on the Network Analyst toolbar and New Closest Facility (Figure 2.3).

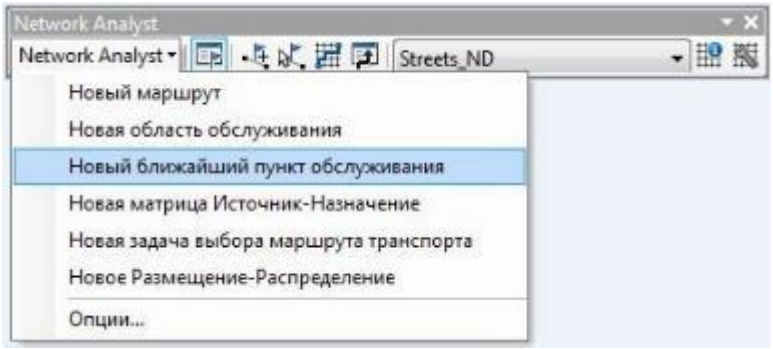


Figure 2.3

The Network Analyst window adds an analysis layer to the nearest service point. Network Analysis Classes - Facilities, Incidents, Routes, Point Barriers, Line Barriers and Polygon Barriers are empty (Fig. 2.4).

Figure 2.4

A new layer of analysis has also been added to the Table Of Contents window (Figure 2.5).

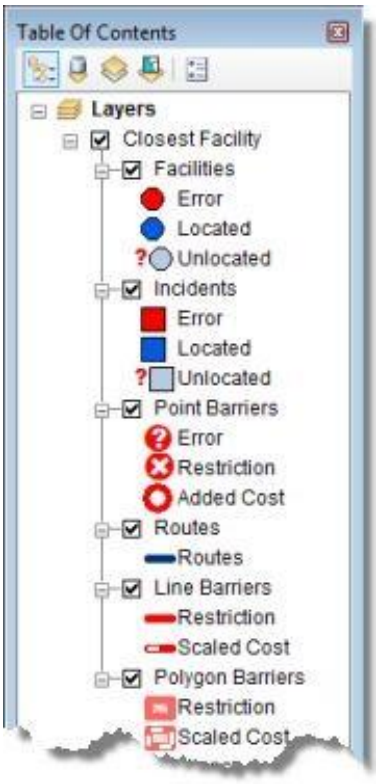


Figure 2.5

Adding service points

Next, you need to download service points from the layer of point spatial objects.

Steps:

1. In the Network Analyst window, right-click the button Facilities (0) and on Load Locations (Fig. 2.6).

Figure 2.6

It will open dialog window Downloads locations (Load Locations).

2. Select Points from the Load From list by following these steps:

a) click Browse for Features or Table to Load. It will open Load Locations dialog box;

b) click on Kharkiv.gdb \ Transportation \ Point;

c) double-click on Point (Fig. 2.7).

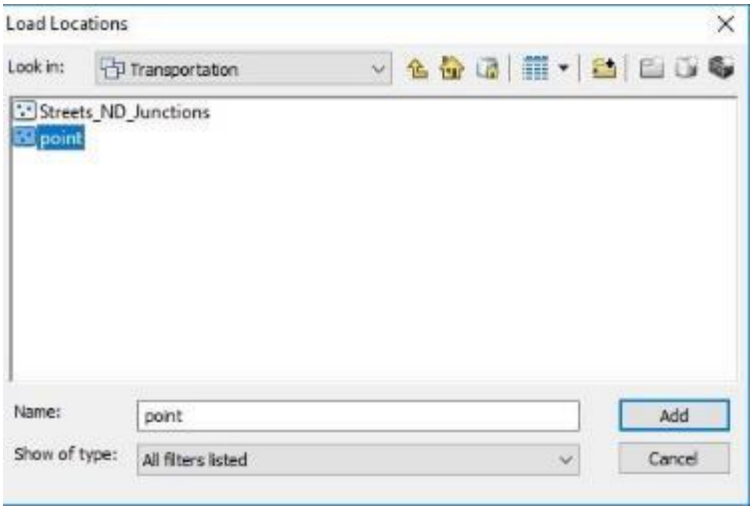


Figure 2.7

3. Click OK in the Load Locations dialog box (Figure 2.8).

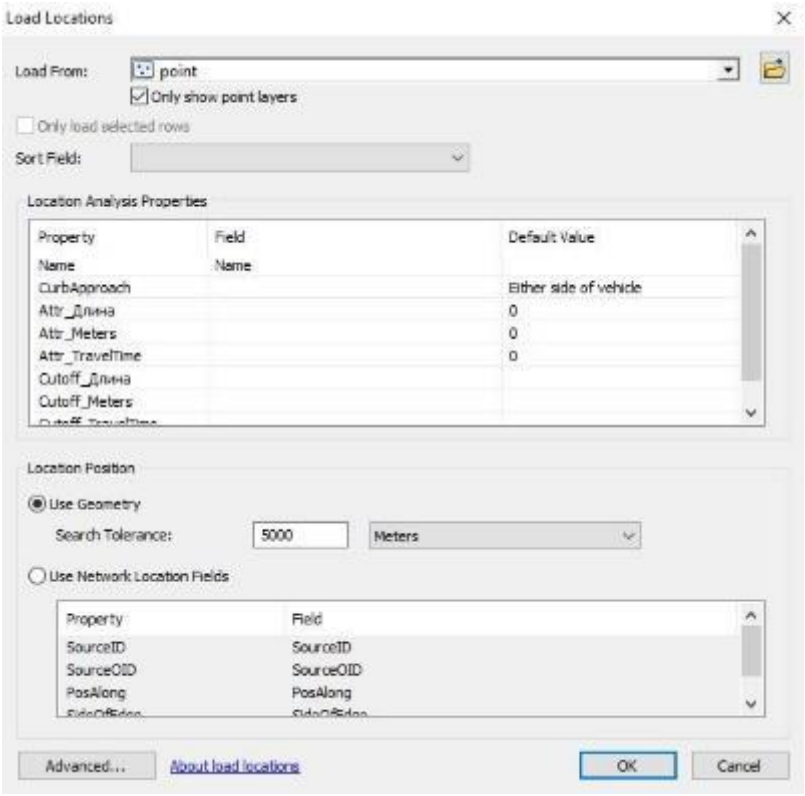


Figure 2.8

Eight objects will be displayed on the map as service points and listed in the Network Analyst window (Fig. 2.9).

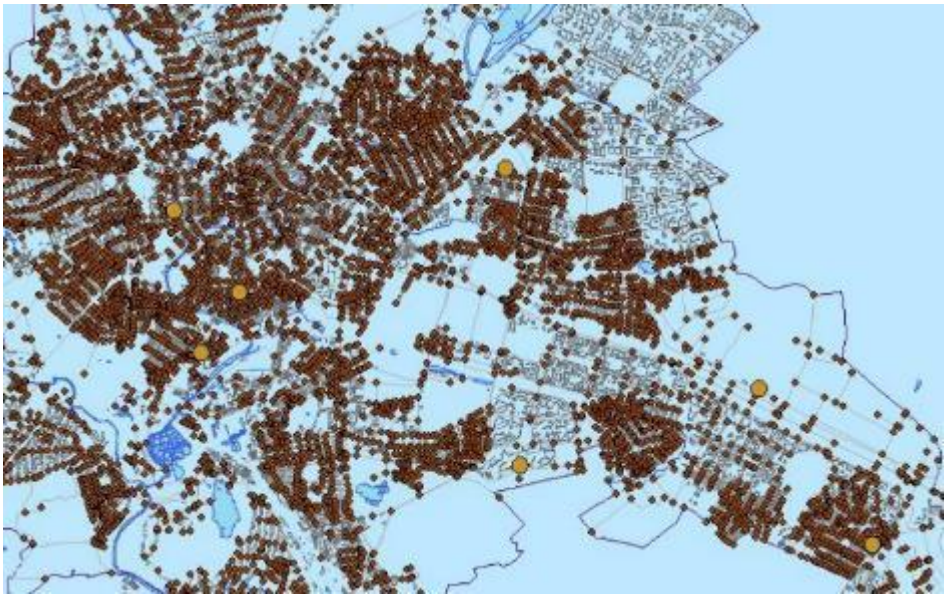


Figure 2.9

Hint. Move the layers of objects from the table of contents and release them in the Network analysis class Facilities, which will allow you to quickly open the Load Locations dialog box.

Add a user location

The incident must be added by geocoding the address received with the emergency call. Steps:

1. Click the Find button panels.

The Find dialog box opens.

2. Go to the Spatial Objects tab (Fig. 2.10).

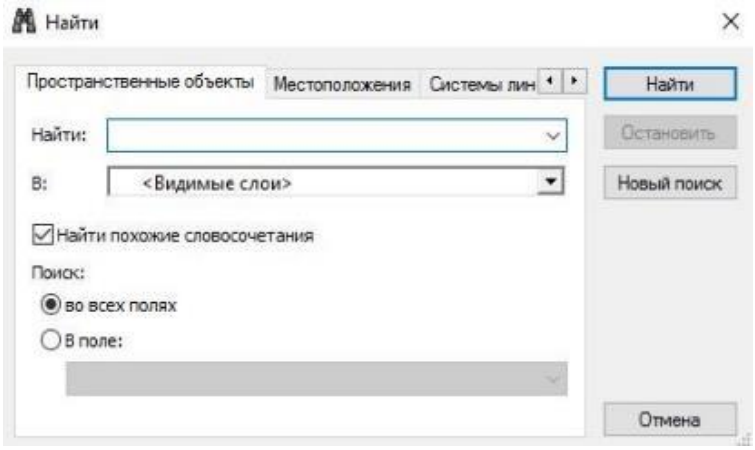


Figure 2.10

3. In the text box, find and enter Sumska, 24. Click on the Find button (Fig. 2.11).

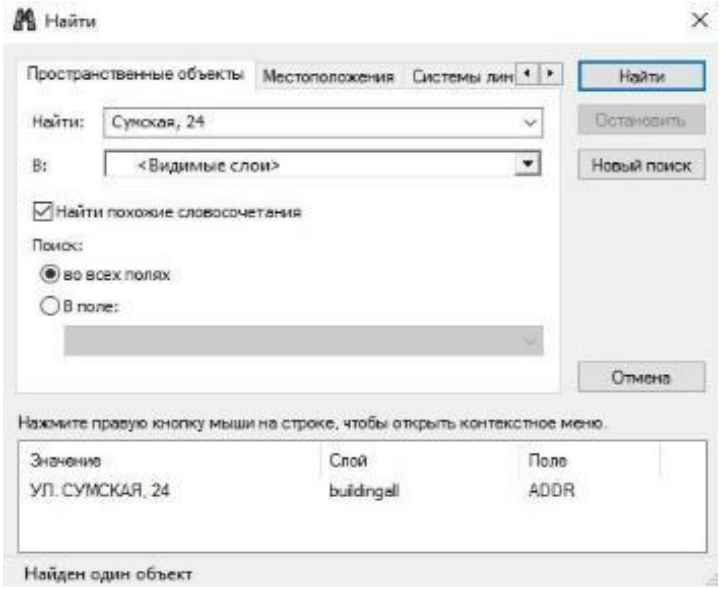


Figure 2.11

4. At this address, one location is defined and listed as a row in the table at the bottom of the Find dialog box.

Right-click on this line and select Add as Network Analysis Object (Fig. 2.12).

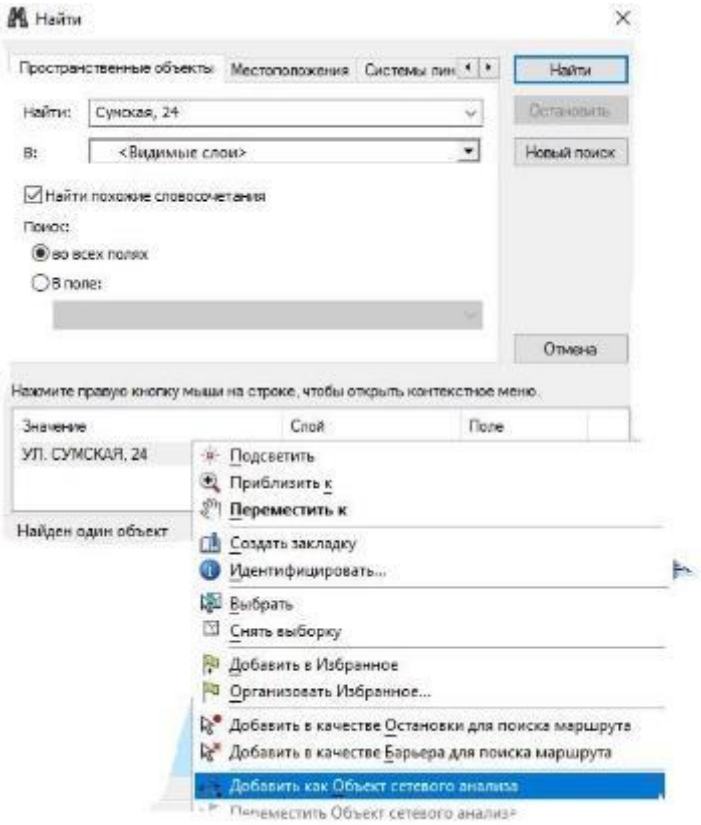


Figure 2.12

The specified address will be added as an incident, which can be seen on the map display and in the Network Analyst window (Fig. 2.13).

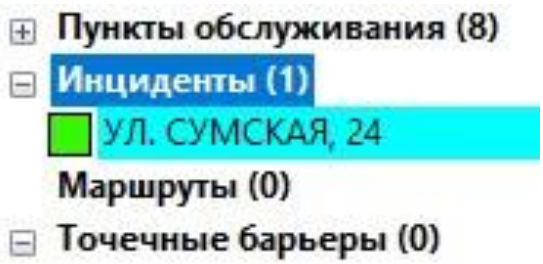


Figure 2.13

5. Close the Find dialog box.

Adjust parameters for analysis

Next, you need to set the parameters for the analysis of the nearest service point.

Steps:

1. Click the Analysis Layer Properties button in the Network Analyst window (Fig. 2.14).

Figure 2.14

The Layer Properties dialog box opens.

2. Click the Analysis Settings tab.

3. Make sure Impedance is defined as TravelTime (Minutes).

4. Do not check Use Time.

The Use Time option allows you to specify the start and end time of the analysis. When using a cost attribute with traffic information, day and date settings, you can determine the nearest service points by setting a dynamic travel time that varies depending on the traffic, but such an analysis will not use time.

5. Enter 10 in the Default Cutoff Value text box.

ArcGIS search for the nearest facilities located a ten-minute drive from the incident at 24 Sumska Street (str. Sumska, 24). Any objects located outside this time period are ignored.

6. Enter 4 in the Facilities to Find field.

ArcGIS search for a maximum of four nearby objects located near the scene of the incident. However, the three-minute restriction still applies; therefore, if the three nearest objects are within a three-minute drive, the fourth object will not be found.

7. Select Facility to Incident for Travel From.

Search results depend on the location of nearby objects loaded as service points.

8. Choose Allowed from the U-Turns at Junctions drop-down list.

9. Click the Output Geometry Type drop-down arrow (Output Shape Type) and select True Shape with Measures.

10. Uncheck Use Hierarchy.

11. Check Ignore Invalid Locations.

12. In the Restrictions box, clear the RestrictedTurns check box.

Cars may not follow the rules of the road in case of emergency.

13. Make sure the Directions box is set to

Distance Units means Kilometers, the Use Time Attribute item is selected, and the Time attribute is set to Travel Time in Minutes (Fig. 2.15).

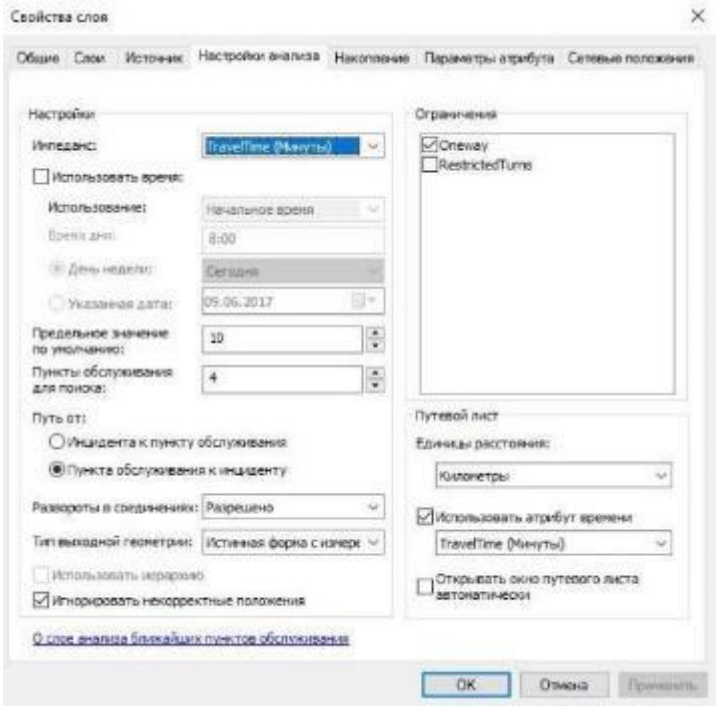


Figure 2.15

14. Click OK.

Identification of the nearest service point

Steps:

1. Click the Solve button toolbar Network Analyst. Routes appear on the map and in the ArcGIS Network Analyst window under the Routes class (Figure 2.16).

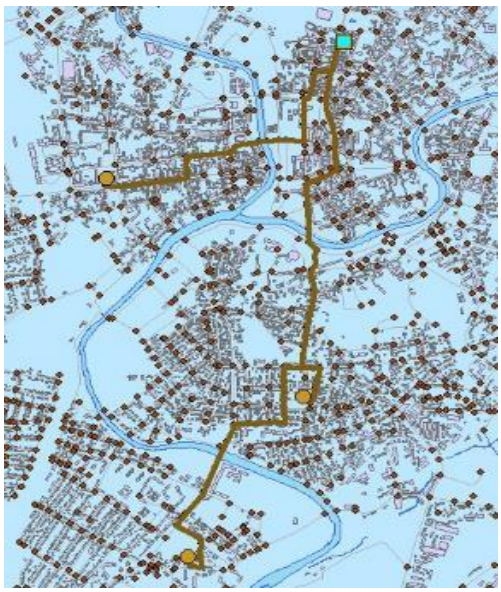


Figure 2.16

Note that the analysis is configured to find four service points within the ten-minute limit; however, only three service points are within this value.

2. Click the Directions Window button toolbar Network Analyst. It will open dialogwindow Directions.

Directions of movement from each nearest object are given in the list in the corresponding window (fig. 2.17).

Путевой лист (Ближайший пункт обслуживания)

[-]	**Маршрут: УЛ. ПОЛТАВСКИЙ ШЛЯХ, 50 - УЛ. СУМСКАЯ, 24**	2,5 км	4 мин.	Карта
1:	Начните движение от УЛ. ПОЛТАВСКИЙ ШЛЯХ, 50			Карта
2:	Поезжайте на восток по Полтавский Шлях в направлении Конева / Малиновского	544 м	< 1 мин.	Карта
3:	Поверните налево на Ярославская	159 м	< 1 мин.	Карта
4:	Поверните направо на Карла Маркса	533 м	< 1 мин.	Карта
5:	Слегка поверните направо на Халтурина	312 м	< 1 мин.	Карта
6:	Поверните налево на Университетская	325 м	< 1 мин.	Карта
7:	Поверните направо на площадь у Бурсы и сразу поверните налево на Мечникова	42 м	< 1 мин.	Карта
8:	Слегка поверните налево на Рымарская	216 м	< 1 мин.	Карта
9:	Поверните направо на Грабовского	105 м	< 1 мин.	Карта
10:	Поверните налево на Сумская	250 м	< 1 мин.	Карта
11:	Завершите движение в УЛ. СУМСКАЯ, 24			Карта
	Время в пути: 4 мин. Протяженность маршрута: 2,5 км			
[-]	**Маршрут: УЛ. КВИТКИНСКАЯ, 27 - УЛ. СУМСКАЯ, 24**	3,1 км	5 мин.	Карта
1:	Начните движение от УЛ. КВИТКИНСКАЯ, 27			Карта
2:	Поезжайте на восток по Квиткинская в направлении Полтавская	54 м	< 1 мин.	Карта
3:	Поверните налево на Полтавская	259 м	< 1 мин.	Карта
4:	Поверните налево на Первой Конной Армии	125 м	< 1 мин.	Карта
5:	Поверните направо на Рыбасовский	316 м	< 1 мин.	Карта
6:	Продолжайте движение по Грековская	445 м	< 1 мин.	Карта
7:	Поверните направо на Урицкого и сразу поверните налево на Урицкого	246 м	< 1 мин.	Карта
8:	Слегка поверните направо на Нетеченский	103 м	< 1 мин.	Карта
9:	Продолжайте движение по Университетская	341 м	< 1 мин.	Карта
10:	Поверните направо на Розы Люксембург	242 м	< 1 мин.	Карта
11:	Слегка поверните налево на Конституции	538 м	< 1 мин.	Карта
12:	Поверните налево на Мечникова и сразу поверните направо	476 м	< 1 мин.	Карта

Опции... Просмотр... Сохранить как... Печать Закрыть

Figure 2.17

If you do not need to continue working with other exercises, close the ArcMap application. Click No to keep the changes.

2.2 Modeling of transport accessibility landfills and location of warehouses

The basis for the development of long-distance passenger transport transport systems is the correspondence of passengers, the receipt of financial resources from which has the appropriate quality characteristics. The object is the state (regional) transport system of Ukraine. The aim is to model the landfills of maximum passenger route transport accessibility, taking into account certain restrictions [30-35].

To achieve the goal defined in the work it is planned to solve the following tasks:

1. To consider the scientific approaches offered by contemporaries on modeling of passenger correspondence between nodes of a transport network.
2. Model the ranges of maximum passenger route transport accessibility for different modes of transport.

Scientists pay a lot of attention to the modeling of passenger route transport systems. As a result of this work, certain tasks were solved to consider not only state (regional), but also urban, interstate and intercontinental route passenger transport systems.

Question intellectual planning urban passenger transport systems were considered by the authors of [17], who proposed an approach based on modeling the demand for dynamic intelligent planning and route optimization. The solution proposed by the authors in the work allows system operators to make decisions on the dynamic creation of new routes based on passenger requests. The model is proposed for implementation in projects Smart City. Modeling of routes within the city was also considered by the authors of the work [18]. They proposed a type of modeling that aims to predict the route network scheme taking into account the maximum interaction between bus and rail routes. The authors of [19] also addressed the issue of the need to take into account coordinated interaction between different modes of transport. They

offered form multimodal transport network, using a multicriteria routing algorithm for modeling.

In [20] the question of the probability of passengers choosing the route of travel, provided there is a set of options. The model of the probabilistic process of bus service is determined. The authors of [21] solved the issue of passenger simulation of the total travel time in the route network depending on the number of transport nodes and the location of stopping points. The issue of improving the efficiency of passenger routes on rail transport is covered in [22]. The authors of [22] simulated the state of the system in the case of changes in the technical parameters of the route.

The authors of [23] comprehensively investigated the effectiveness of the route passenger transport system. The developed mini-model is based on different modes of transportation and a multimodal public transport system. The paper proposes to apply flexible schedule optimization based on flexible modeling of car size. In [24] the results of researches of modeling of fluctuations of demand in case of transit operation of a bus route are presented. The approach to modeling the demand for travel and its distribution in accordance with the limitations of the volume at the zonal level, which are as mandatory as the capacity limitations of general references, considered in [25-27]. The authors of [28] studied the impact of the volume of passenger correspondence as the main resource, affecting the development of transport infrastructure. Their influence is determined and the mentioned processes are modeled.

The authors of [29] developed an algorithm for determining the area of distribution of road routes, taking into account the geographical location of railway passenger networks. Based on the proposed algorithm, a model of planning bus routes for railway stations has been developed. The authors of [30] considered the issue of the impact of population demand on the speed of movement. Changes in the functioning of passenger transport systems have been studied by other authors in [31–33].

In [34] it was determined that the main characteristic of the transport system is its accessibility. The paper considers the approach to modeling regional accessibility. The authors of [35] considered the issue of increasing population mobility. It is determined that the productivity of public transport is limited not only by its

accessibility, but also by its capacity. The actual capacity of the transport line is determined by the operating frequency, as well as the physical capabilities of each vehicle. The relationship between loaded demand and capacity helps to establish levels of comfort, including quality of service in general. Consideration of these phenomena in the destination model, which describes the user of the route and the mode of choice, as well as transportation of supplies should be limited to the capacity of vehicles (seats and standing places), movements during boarding and disembarking,

[36] simulates the actual behavior of the passenger when choosing travel options that combine travel by public transport and car or bicycle. The definition of the network is based on the formation of the implemented set of route options with the choice of their optimal combination. The method and indicators of quality network quality assessment are offered.

Among such approaches we can single out the one proposed in [37–42], used to predict the flow of passengers between different geographical locations.

To create a series of landfills that can be reached from a service point over time, three-, five-, and ten-minute service areas have been calculated for six warehouses in Kharkiv. These landfills are a service area.

You also need to determine how many stores are located in each of these service areas. It is necessary to choose a warehouse, the location of which is optimal for quality service of the store. Additionally, you need to create a Source-Destination matrix to deliver goods from the warehouse to all stores within 20 minutes. This matrix is used as an input for logistics, supply and route analysis.

Steps:

1. Attach the Road Network file to ArcMap.
2. Activate the ArcGIS Network Analyst plug-in by running

the following actions:

a) click on Customize> Additional modules (Extensions). The Extensions dialog box opens;

b) mark ArcGIS Network Analyst;

c) click Close.

3. If the Network Analyst toolbar doesn't appear yet, you'll need to add it;

Click Customize> Toolbars> Network Analyst.

The Network Analyst toolbar will be added to ArcMap (Figure 2.18).

Figure 2.18

4. If the Network Analyst window doesn't appear yet, you'll need to add it.

On the Network Analyst toolbar, click Network Analyst window .

The attached Network Analyst window will open (Fig. 2.19).

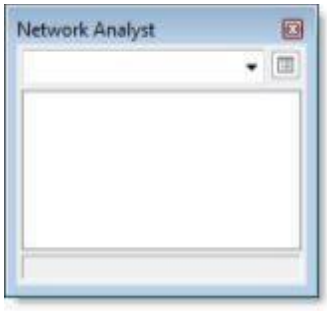


Figure 2.19

The Network Analyst window can be pinned and unpinned.

Creating a service area analysis layer

Click Network Analyst on the Network Analyst toolbar and New Service Area (Figure 2.20).

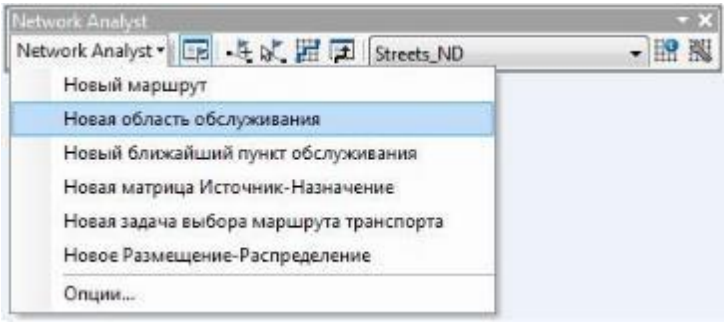


Figure 2.20

The service area analysis layer will be added to the Network window Analyst. Network analysis classes: Facilities, Polygons, Lines, Point Barriers, Line Barriers and Polygon Barriers - empty 2.21).

Figure 2.21

A new layer of analysis has also been added to the Table Of Contents window (Fig. 2.22).

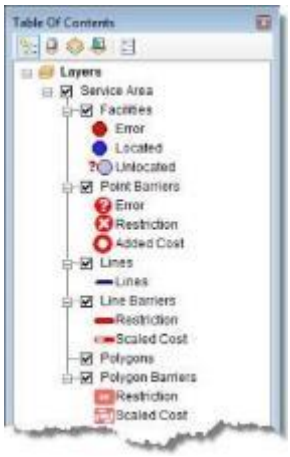


Figure 2.22

Adding service points

Next, it is necessary to add warehouses as service points for which service area landfills will be generated.

Steps:

1. Press CTRL while moving the Warehouses layer from the Table of Contents window and release it above the Facilities class in the Network Analyst window.

The six warehouses will be loaded as service points and will appear on the map.

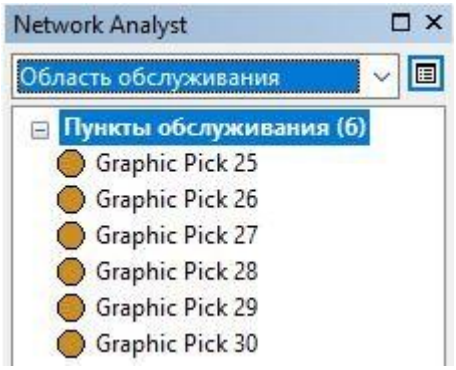


Figure 2.23

2. In the Network Analyst window, click on the plus sign (+) next to Service Points (6) (Facilities (6)) to see a list of service points (Fig. 2.23).

Setting parameters for analysis

The next step is to calculate the service area based on travel time (in minutes). Calculate the trm service area polygons for each service point alternately for three, five, and ten minutes. It should be noted that the movement will take place from the service point, not to it, reversals are allowed and restrictions must be observed on one-way streets.

Steps:

1. Click the Analysis Layer Properties button in the Network Analyst window (Fig. 2.24).

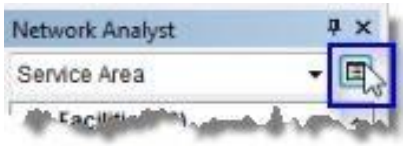


Figure 2.24

The Layer Properties dialog box opens (Fig. 2.25).

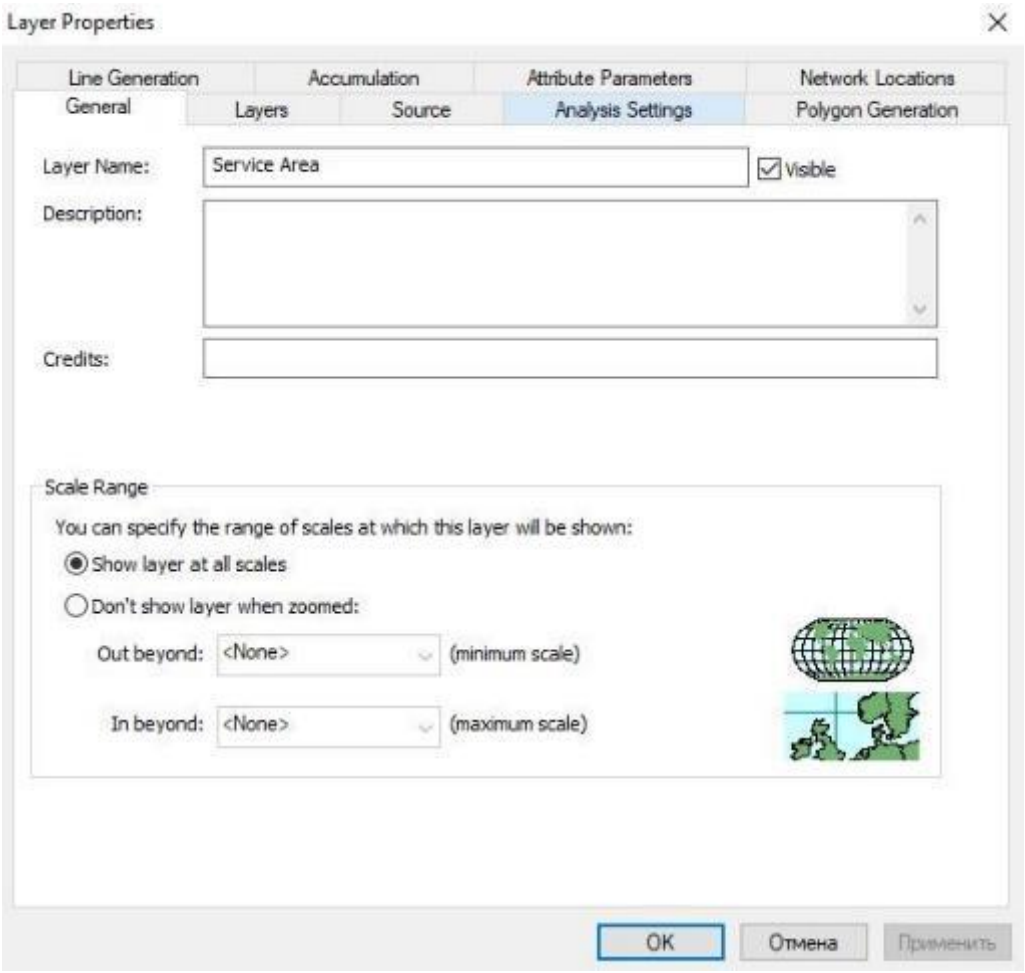


Figure 2.25

2. Click the Analysis Settings tab.
3. Make sure the Impedance is set to Drive Time (in minutes).
4. Enter 3, 5, 10 in the Default Breaks text box.
5. IN section Direction click on From Away From Facility.
6. Select Not Allowed from the list, U-Turns at Junctions.
7. Check Ignore incorrect placements (Ignore Invalid Locations).
8. Mark One-sided movement (One way) in menu Restrictions.

The Analysis Settings tab should look like this (Figure 2.26).

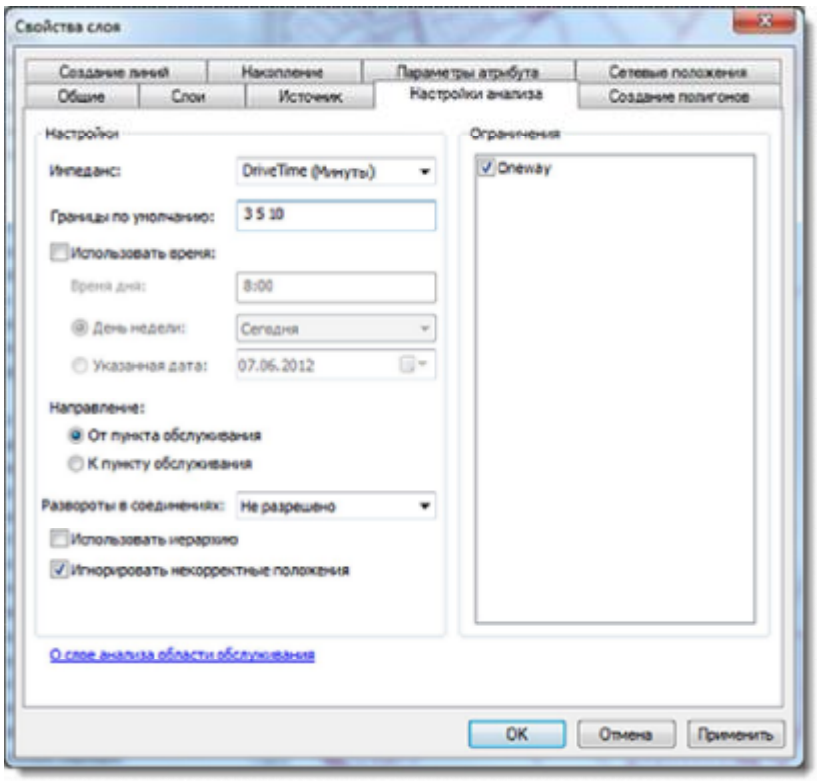


Figure 2.26

9. Click the Polygon Generator tab.

10. Make sure Generate Polygons is selected.

11. To set the Polygon Type, click Generalized. Detailed polygons are more accurate, but they take longer to generate.

12. Uncheck the Trim Polygon option.

The post-cultivation process cuts the outer boundaries of the landfill to remove emissions, and additional time is required.

13. Click Overlapping to go to the window Parameters for multiple service points (Multiple Facilities Options).

Separate landfills are created for each service point. The landfill of one service point may overlap with the landfill of another, the nearest service point.

14. Click Rings for Overlap. This excludes areas with lower limits from landfills with large boundaries.

15. Click Apply to save the settings.

16. Click the Line Generation tab. Do not check Generate Lines.

Although the lines from the edges that intersect in this exercise will not be generated, you can do so using this option.

It can be applied to baselines, landfills or both.

17. Click OK.

Service area calculation

Steps:

1. Click the Solve button toolbar Network Analyst. Service area landfills will appear on the map and in the Network Analyst window. Landfills are transparent, which allows you to see the streets below them. However, instead of setting the transition from dark to light in the case of increasing the distance, you need to change the settings for the transition of color from light to dark.

2. In the Table Of Contents, right-click the Polygons sublayer and select Properties.

3. Select the Symbology tab.

4. Click on the name of the Symbol field and select Flip Symbols (you need to make sure that Symbol is clicked with the left, not the right mouse button, otherwise you will not see the context menu) (Fig. 2.27).

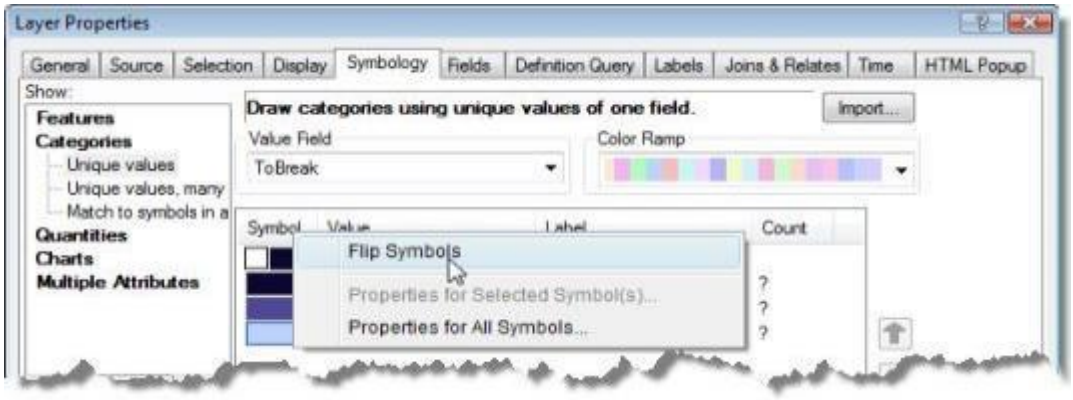


Figure 2.27

5. Click OK.

The outer and inner service areas are distributed by the color of the switch, providing a clearer view of the areas beyond ten-minute values (Fig. 2.28).

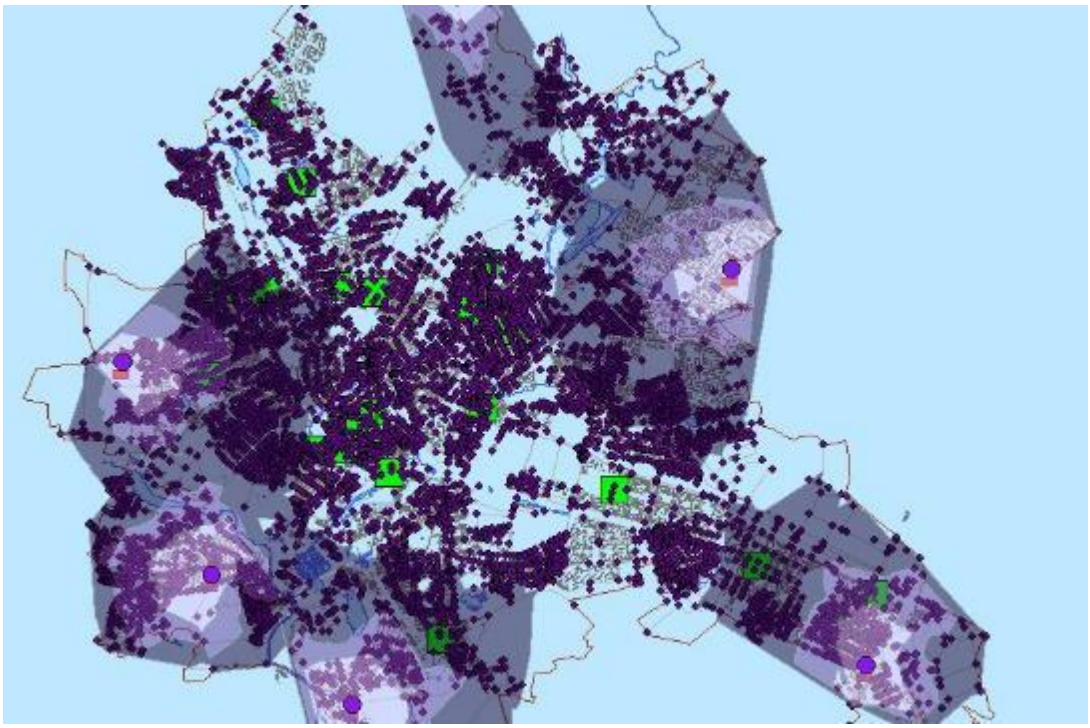


Figure 2.28

Identification of stores located outside the service areas

Steps:

1. In the Table Of Contents window, click and move the Stores at the top of the Layers list to improve visibility (Fig. 2.29).

Figure 2.29

2. Click on Select (Select By Location) (Fig. 2.30).

Figure 2.30

3. Create a sample query in the Select By Location dialog box to select items from stores inside the landfills, as shown in Figure 2.31.

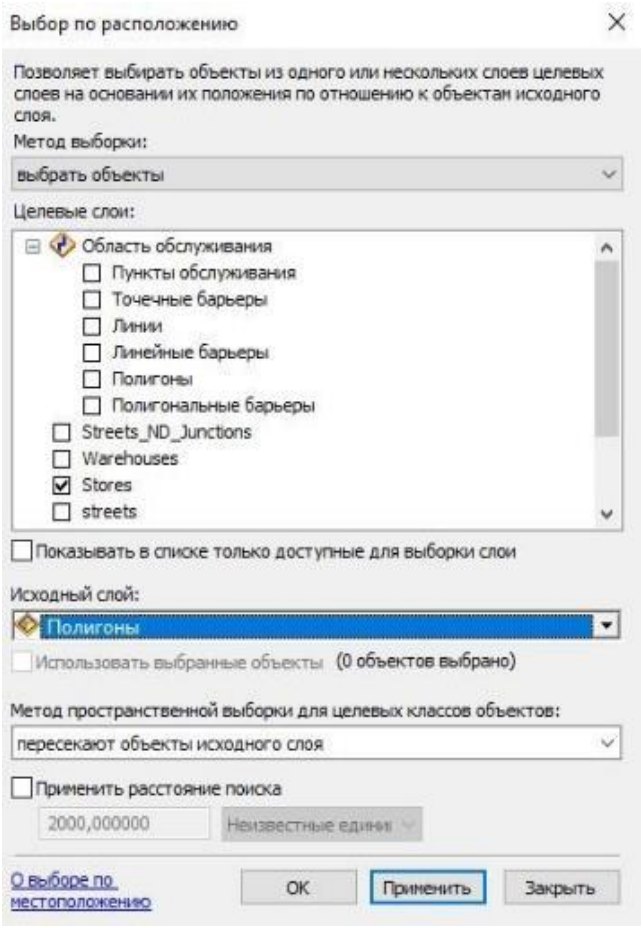


Figure 2.31

4. Click OK.

The shops located within the landfills, behind the landfills of the service area, are selected.

5. In the Table Of Contents window, right-click Stores and on Selection> Switch Selection.

The sample will show the distribution of stores that were not located in the service area. This sample is used to determine to which area the warehouse will be transferred. The best are the areas located in the center of the map (Fig. 2.32).

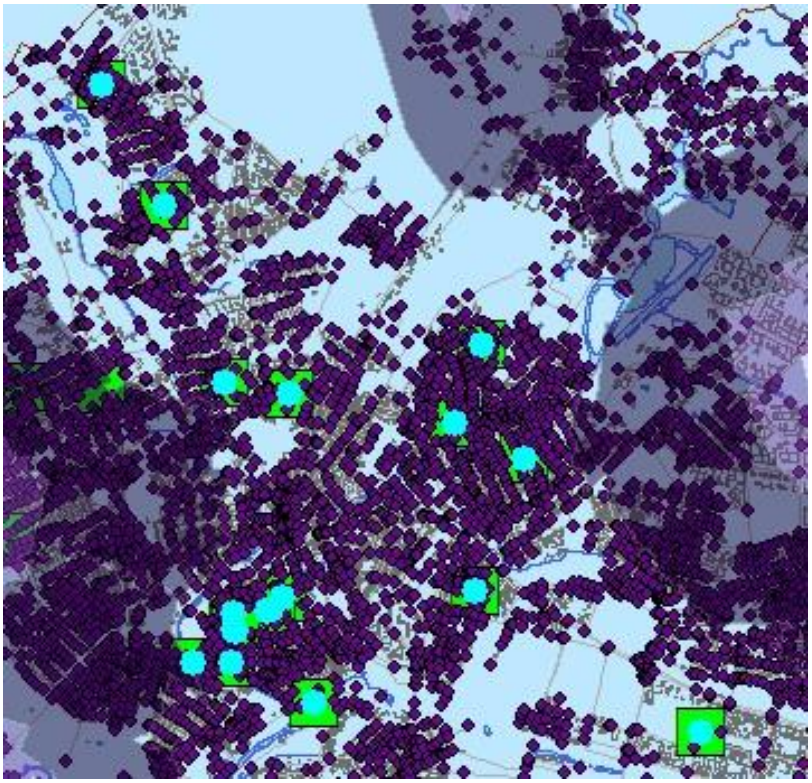


Figure 2.32

6. On the Tools toolbar, click the Clear Selected Features button.

Moving the least available warehouse

It is clear from Figure 2.32 that there are no stores within the three-, five- or ten-minute availability areas of the service area around warehouse № 3 (Graphic Pick 27), so this warehouse needs to be relocated for better store service.

Steps:

1. In the Network Analyst window, select Warehouse № 3 (Graphic Pick 27) under Facilities (6) (Fig. 2.33).

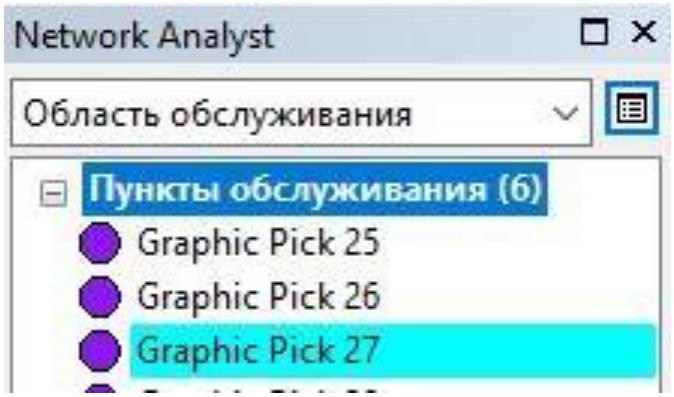


Figure 2.33

2. Click on tools Select / Move Select / Move Network Location Network toolbar Analyst.

3. Move the warehouse № 3 to the center of the map as shown in Figure 2.34.

4.

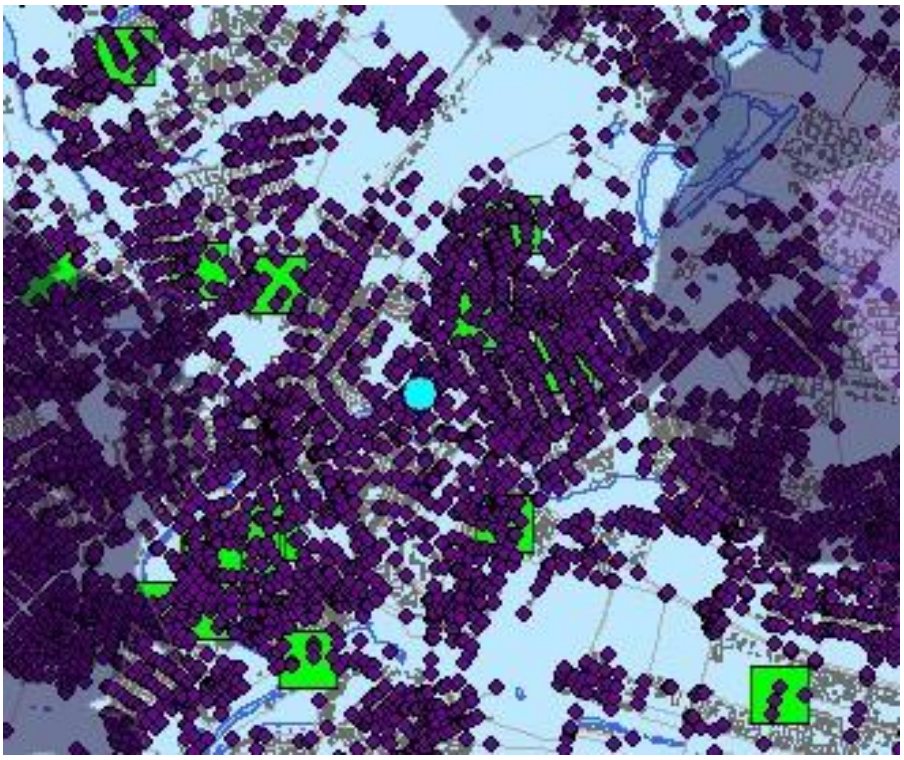


Figure 2.34

5. Start the service area calculation process. To do this, click the Solve button Network Analyst toolbar.

Service area landfills will appear on the map and in the Network Analyst window.

Identification of the landfill service area in which all stores are located

Steps:

1. In the Table Of Contents window, right-click Stores and Joins and Relates> Join (Figure 2.35).

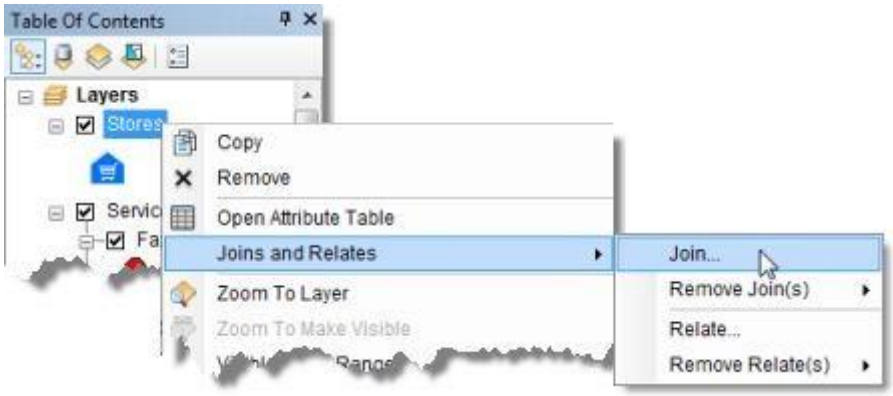


Figure 2.35

The Join Data dialog box opens.

2. Choose Data from another layer based on position spaces (Join data from another layer based on spatial location) (Fig. 2.36).

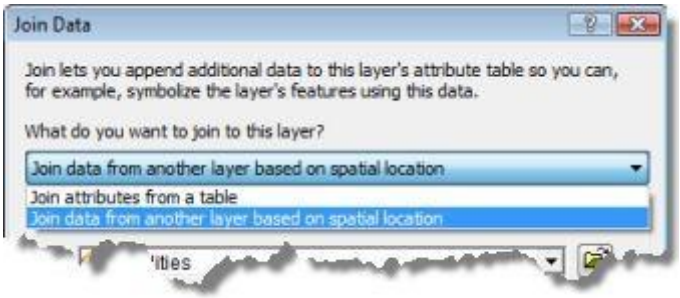


Figure 2.36

3. Select Polygons as the layer to connect to the previous layer (Figure 2.37).

Figure 2.37

4. Click on the button "inside" which it got (Fig. 2.38).

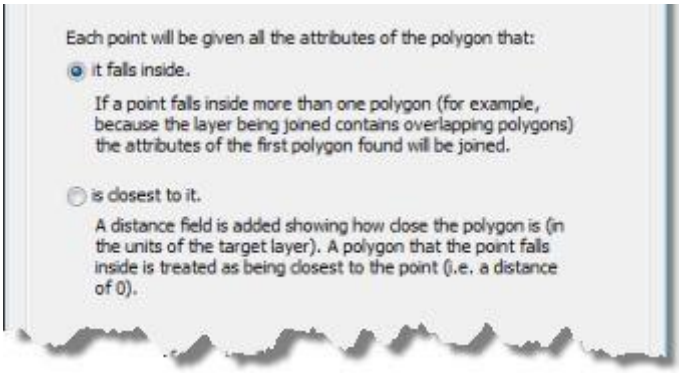


Figure 2.38

In this way, the attributes of the polygon are added to all points that fall inside the polygon.

5. Specify Location weekend shapefile or class of spatial objects to save the results of the connection and name them Stores With Poly (Fig. 2.39).

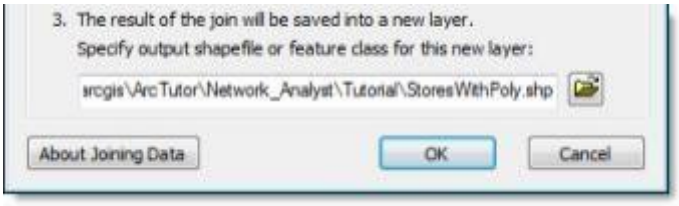


Figure 2.39

6. Click OK.

ArcGIS connects and adds a new layer to the map document.

7. In the Table Of Contents, right-click a new layer of Stores With Poly objects and select Open Attribute Table.

Each row in the table contains the name of the store and landfill to which it belongs. You can use this table to generate other useful categories, such as the number of stores within 0 to a three-minute availability area.

8. Close the attribute table.

9. Additionally, you can export service points (including relocated ones) as classes of spatial objects.

In the Network Analyst window, right-click Facilities (6) and select Export Data.

The Export Data dialog box opens.

10. From the Export list, select All features.

11. Choose the original location and type (shapefile or class) of spatial objects.

You can select a geodatabase to save the feature class

Paris: C: \ arcgis \ ArcTutor \ Network Analyst \ Tutorial \ Kharkiv.gdb \ Export_Output (Fig. 2.40).

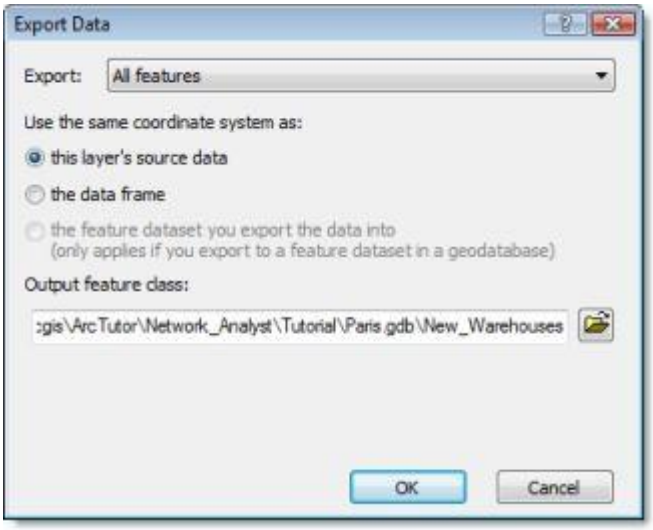


Figure 2.40

12. Click OK.

Will appear message from question or you want you add exported data to the map.

13. Click No.

No data is required for the rest of this exercise.

Creating a layer of analysis of the source-destination matrix

Additionally, it is necessary to create a Source-Purpose matrix for the delivery of goods from the new warehouse to all stores. The results of this matrix can be used to identify the stores that will be serviced by each warehouse located within twenty minutes of travel time. In addition, you can determine the travel time from each warehouse to the appropriate store.

Steps:

1. In the Table Of Contents, uncheck the Service Area analysis layer and the Stores With Poly object layer to improve map readability.

2. Click Network Analyst on the Network Analyst toolbar and the New OD Cost Matrix (Fig. 2.41).

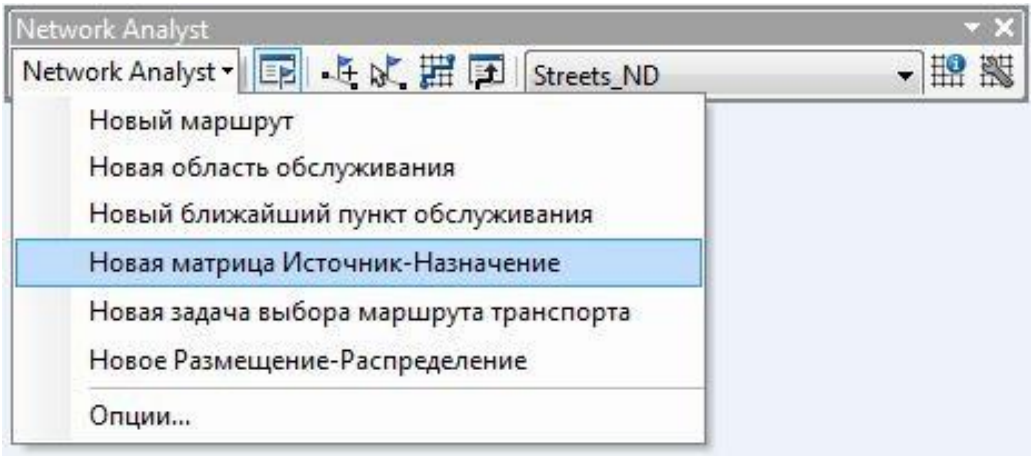


Figure 2.41

The Source-Destination matrix analysis layer has been added to the Network window Analyst. Network analysis classes: Origins, Endpoints (Destinations), Lines, Point Barriers, Line Barriers and Polygon Barriers are empty (Fig. 2.42).

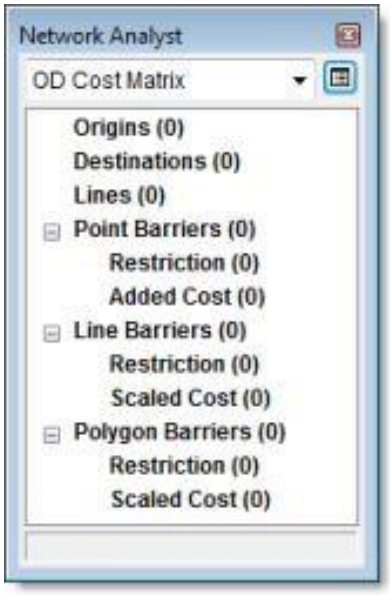


Figure 2.42

A new layer has also been added to the Table Of Contents window analysis (Fig. 2.43).

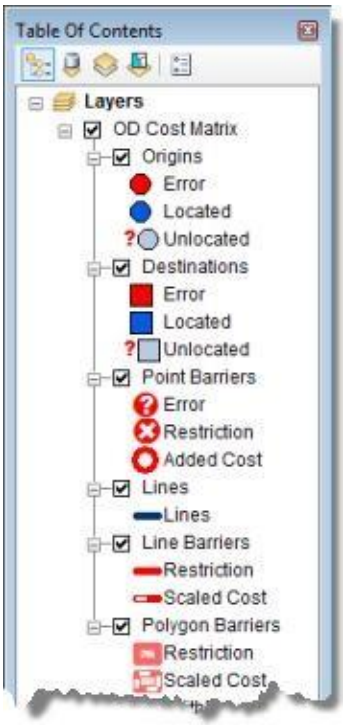


Figure 2.43

Adding origins

Service area service points can be used as sources (previous sections). If you use all partitions in service areas, you can use a layer of spatial objects instead.

Steps:

1. In the Network Analyst window, right-click on Sources (Origins (0)) and select Load Locations. The Load Locations dialog box opens.

2. Click on ServiceArea / Facilities in the list, Load From (if the previous section in the service area is not completed, select Warehouses instead).

3. Uncheck Only load selected rows.

4. In the Location Position section, click Use Network Location Fields (If loading warehouses are loaded, click Use Geometry).

Using network location fields allows ArcGIS to use an already located service area position to redefine them as a source. This method provides a quick re-determination of the location of the object compared to the spatial search (Fig. 2.44).

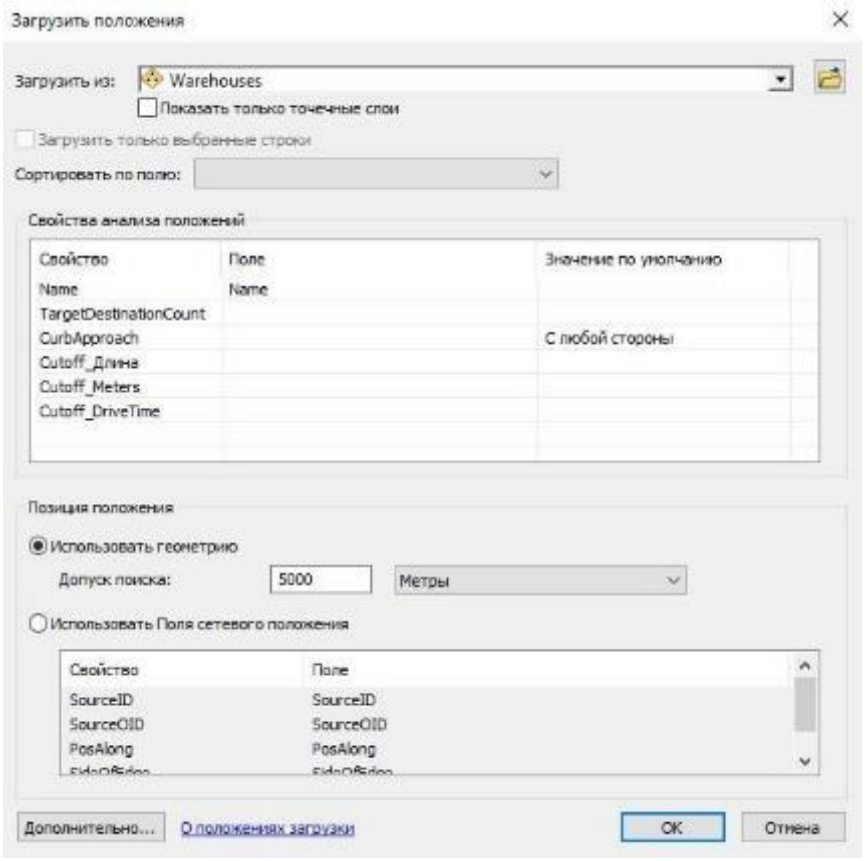


Figure 2.44

5. Click OK.

Six new objects are displayed in the Network Analyst window in the Origins section (Figure 2.45).

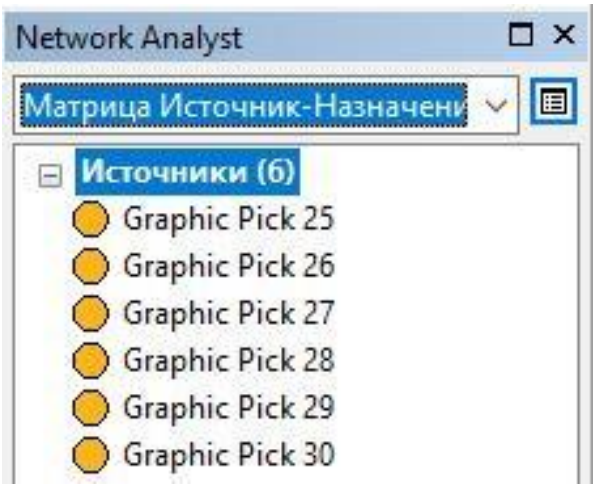


Figure 2.45

Add appointments

Steps:

1. In the Network Analyst window, right-click the Destination button (Destinations (0)) and choose team Load Locations.

2. Select Stores from the Load From list.

3. In the Location Analysis Properties section, select Name for the property name in the Field list.

Until the English name of the field Name is configured in the file NASolverConfiguration.xml, ArcGIS will not be able to automatically match the name of the field with the map (Fig. 2.46).

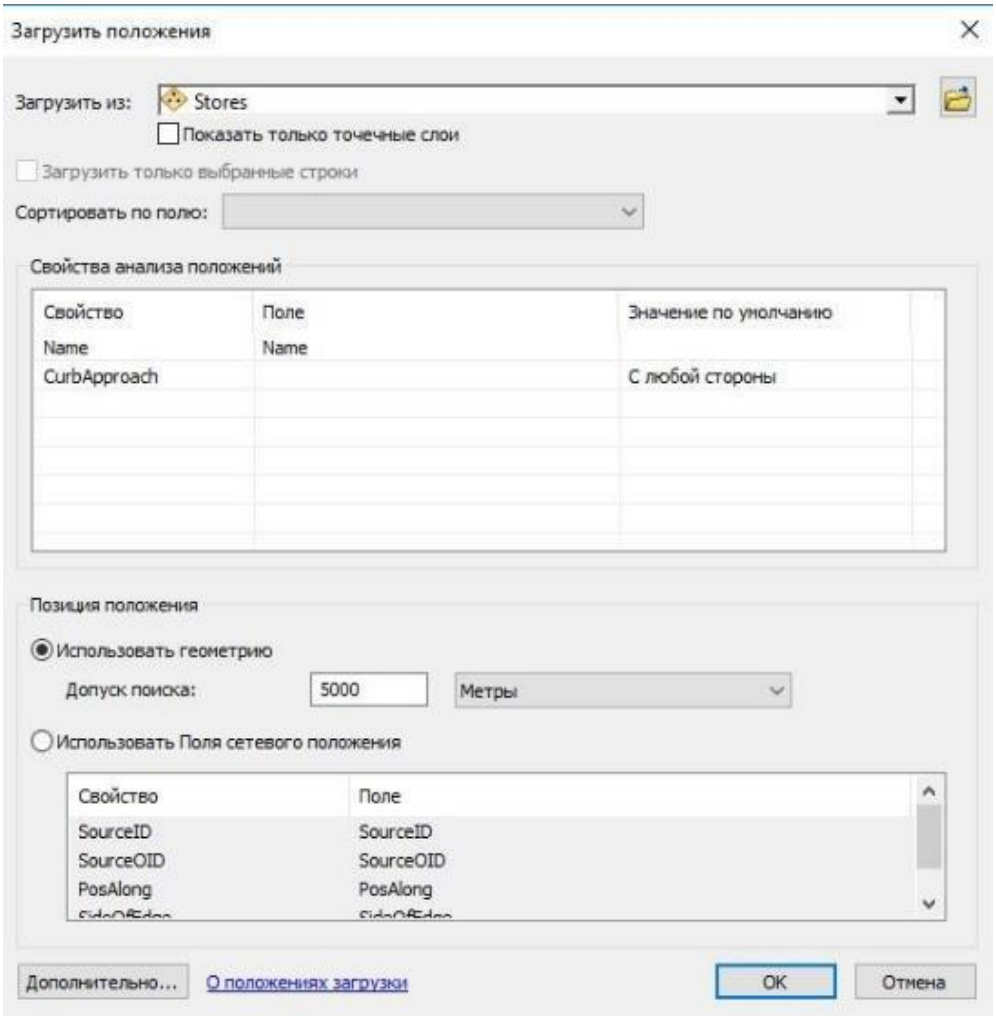


Figure 2.46

4. Click OK.

The Network Analyst window contains a list of 25 destinations (Fig. 2.47).

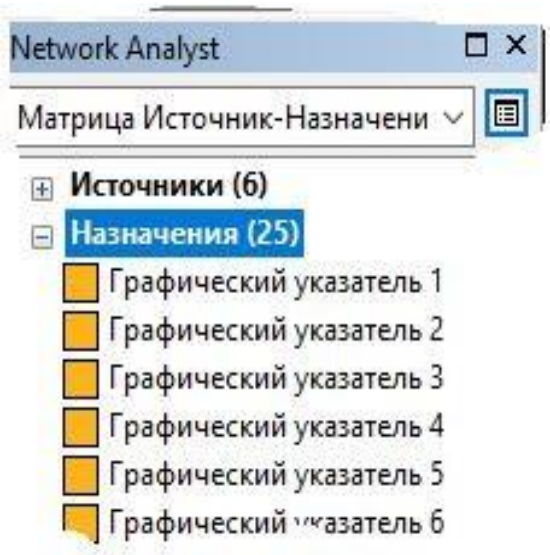


Figure 2.47

These values are displayed on the map (Fig. 2.48).

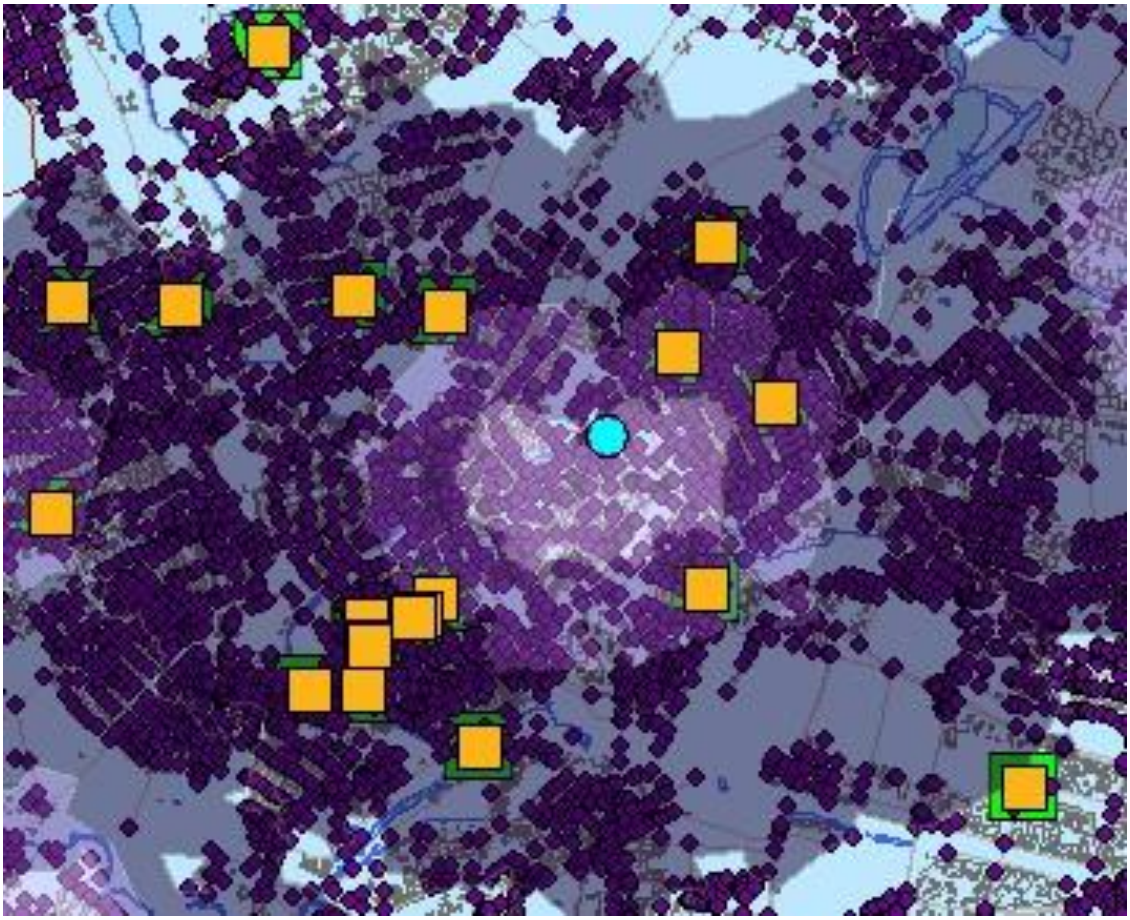


Figure 2.48

Setting parameters for analysis

At the next stage it is necessary to calculate the matrix SourceAppointment by travel time. You must set the default reduction value to 20 minutes and adjust the settings so that all destinations are within the restricted area. Additionally, it should be noted that reversals are always allowed, and the original geometry must be straight. As the route is performed on the road, one-way traffic restrictions should be taken into account. All invalid placements (location not found) are ignored.

Steps:

1. Click the Analysis Layer Properties button in the Network Analyst window (Fig. 2.49).

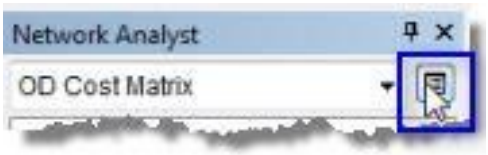


Figure 2.49

2. Click the Analysis Settings tab.
3. Make sure the Impedance drop-down list is set to Drive Time (in minutes).
4. Do not check Use Start Time.
5. Enter 20 in the Default Cutoff Value text box.

In this way, Source-Destination directions will be created from each warehouse to all stores located within 20 minutes of the route. Minutes are used as units because the impedance attribute is specified in minutes.

6. Make sure the <All> property of the Destinations To Find properties is set.
7. Select Allowed from the U-Turns at Junctions drop-down list.
8. Make sure the Output Shape Type section is set to Straight Line.
9. Make sure Ignore Invalid Locations is selected.
10. Check One way in the Restrictions menu (Restrictions) (Fig. 2.50).

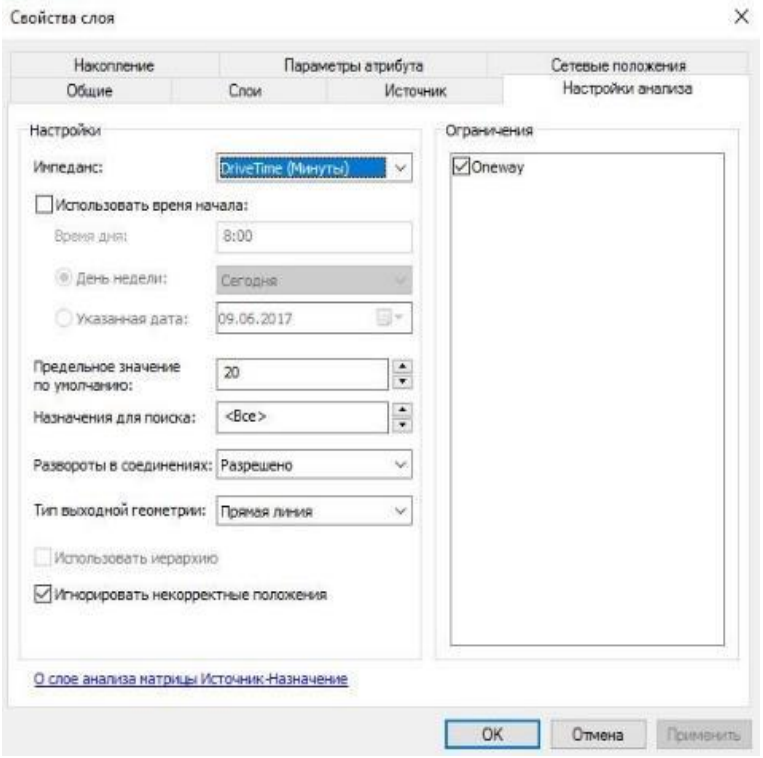


Figure 2.50

11. Click OK. Settings saved.

Start the process of creating a source-destination matrix

Click the Solve button Network Analyst toolbar. Source-Destination lines will be displayed on the map. In this example - 74 lines (Fig. 2.51).

Figure 2.51

This number will depend on where the warehouse is moved № 3 (Fig. 2.52).

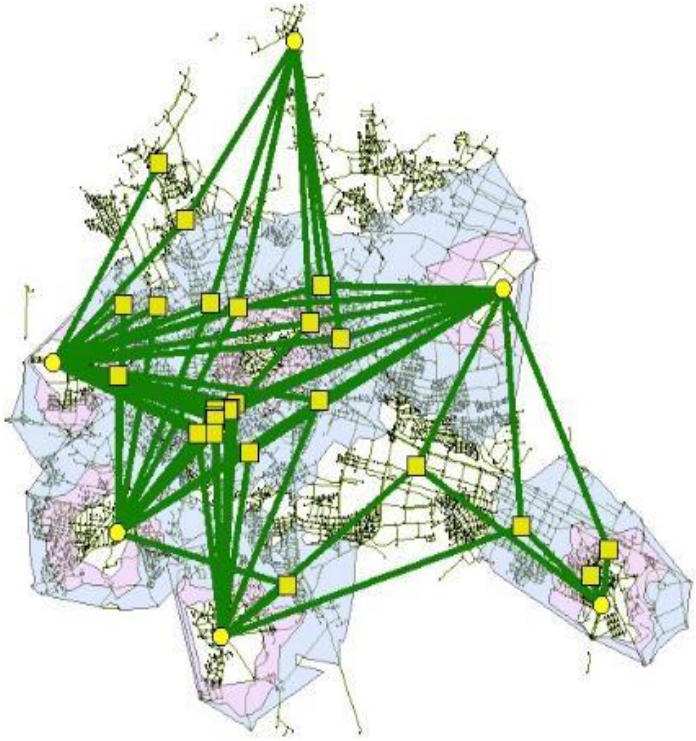


Figure 2.52

If layer area service not will be displayed turn on the matrix layer display Source-Purpose in the upper part of the service area of warehouses.

Allocation of shops for warehouses

The Source-Destination matrix can be used to identify the stores that will be serviced by each warehouse.

Steps:

1. In the Network Analyst window, right-click Lines (74) and select Open Attribute Table (Fig. 2.53).

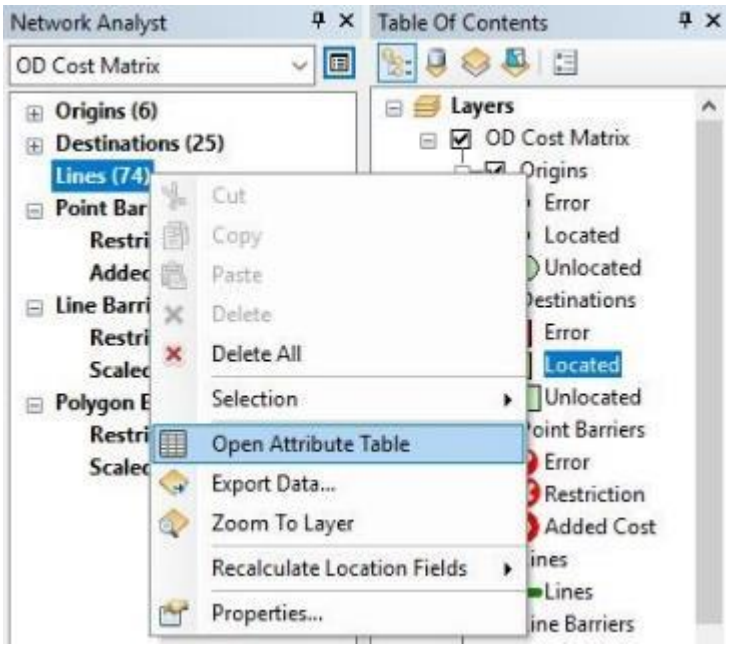


Figure 2.53

The Lines table opens.

The Lines table is a Source-Destination matrix from each warehouse to all stores within 20 minutes. The OriginID column contains the identifiers of the warehouses. The Destination ID column contains store IDs. Destination Rank is the rank assigned to each destination served by the store based on the total travel time. For example, in the table (Fig. 2.54) it is indicated that for warehouse № 1 destination identifier 2 (Destination ID 2) has rank 1, and destination ID 3 has rank 2. This is due to the fact

that the path from warehouse № 1 to Destination ID 2 takes less time (this case may differ because the results of the analysis depend on the source class of spatial objects of sources and purposes).

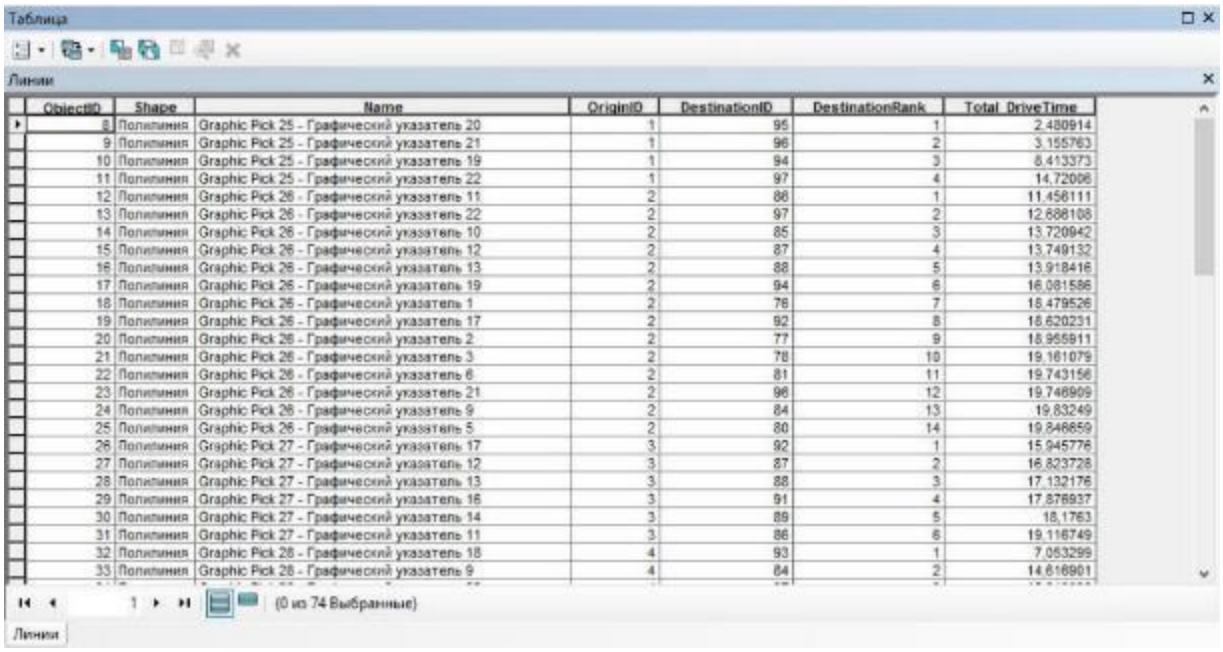


Figure 2.54

The Source-Destination matrix displays the stores serviced by each warehouse, along with the total travel time for each route. Some stores are within a 20-minute reach of more than one warehouse and can be serviced by any of them. The Source-Destination Matrix can also be used as an introduction to logistics routing models that use source destination matrices to separate goods and services.

2. If you do not need to continue working with other exercises, close. ArcMap application. Click No to save the changes.

3. If you need to work with other exercises, you need to do the following actions.

a) open File> New. A dialog box will appear New Document;

b) click OK;

c) Click No in response to the request to save changes.

Similarly, the models of maximum passenger route transport accessibility for different types of transport were modeled using the geographical model of the transport network of Ukraine. In the selected model of the network, regional centers are defined as transport nodes, links - highways of state and regional importance and railways (Fig. 2.55, 2.56).

Figure 2.55

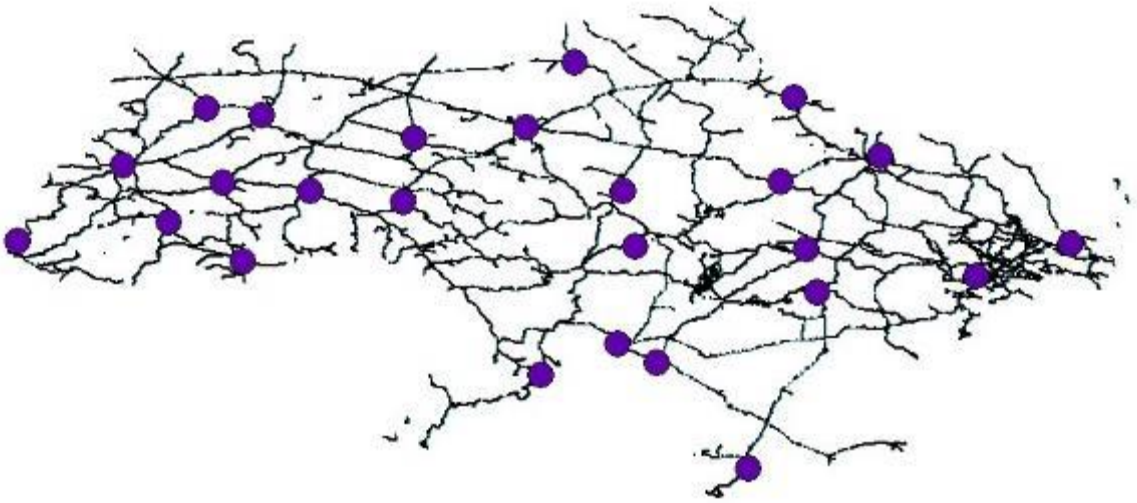


Figure 2.56

The figures show that the road and rail transport networks are different. The number of links in the car network is greater, it provides the opportunity to build landfills that differ from each other. The selected models of transport networks meet the requirements for the reliability of data with tolerable geographical deviation. This allows you to use the selected model for further research. ArcGIS software (Network Analyst application) was used to model the polygons of maximum passenger route transport accessibility for different types of transport.

Transport accessibility landfills have been built for transport nodes, taking into account certain conditions of the transportation process - average time and average driving speed. When modeling the landfills of the maximum passenger route accessibility of the transport system, the average driving time for road transport was chosen to be equal to 1.5; 3; 5 and 8 h, and the average speed of connection is 46 km / h and 73 km / h, which corresponds to the speeds of interregional bus service used in the research system. Models of landfills for maximum passenger route transport accessibility for road transport at transport hubs, which correspond to such regional centers as Luhansk, Odesa, Dnipro, Kyiv, Simferopol, have been built. Figures 2.56–2.58 show the results of modeling on the example of a landfill, built relative to the transport hub corresponding to the city of Dnipro: model of landfills of maximum passenger route transport accessibility by road at a speed of 46 km / h and a driving time of 1.5; 3; 5 and 8 hours, respectively (Fig. 2.57); model of landfills of maximum passenger route transport accessibility on motor transport at a speed of 73 km / h and a driving time of 1.5; 3; 5 and 8 hours, respectively (Fig. 2.58).

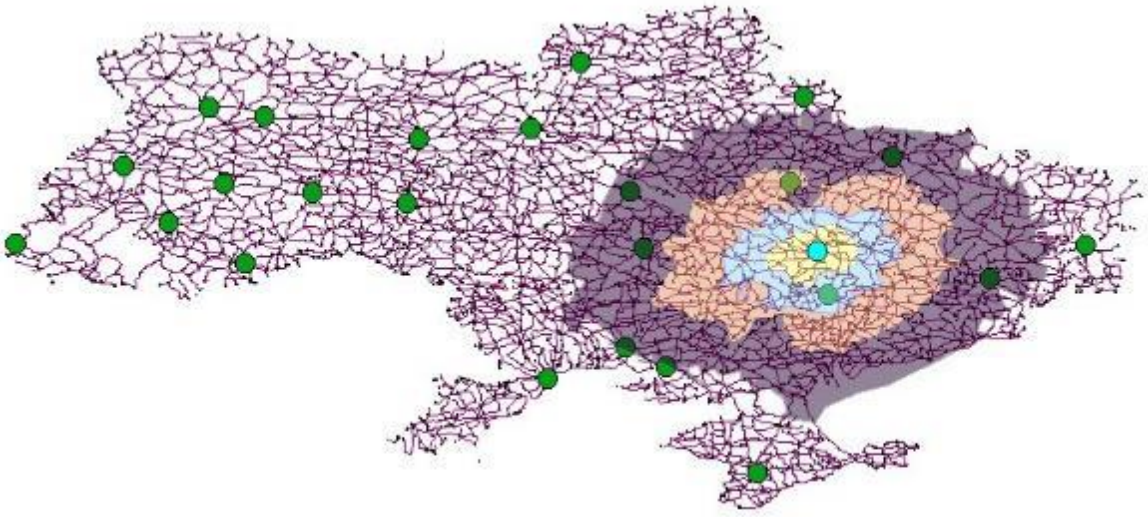


Figure 2.57

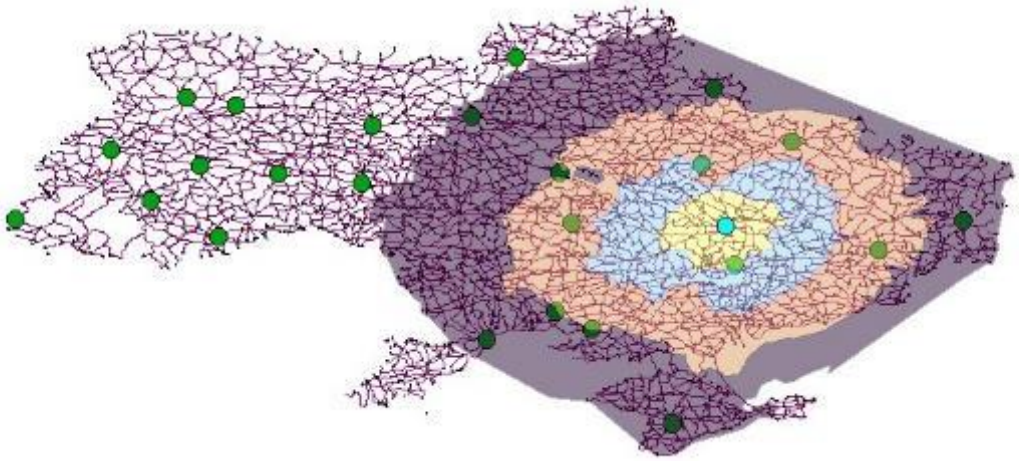


Figure 2.58

Similar models, taking into account the limitations of transport accessibility 1.5; 3; We are building 5 and 8 o'clock for railway transport. The following speed limits were used during the simulation, namely: 31 km / h, 68 km / h and 98 km / h, which corresponds to the speeds of interregional railway connections used in the research system. The simulation results are shown in Figures 2.59–2.61 on the example of a landfill built relative to the city of Dnipro: model of landfills for maximum passenger route transport accessibility on railway transport for certain parameters (31 km / h, 1.5, 3, 5, 8 h) (Fig. 2.59); model of landfills of maximum passenger route transport

accessibility on railway transport for certain parameters (68 km / h, 1,5, 3, 5, 8 h) (Fig. 2.60);

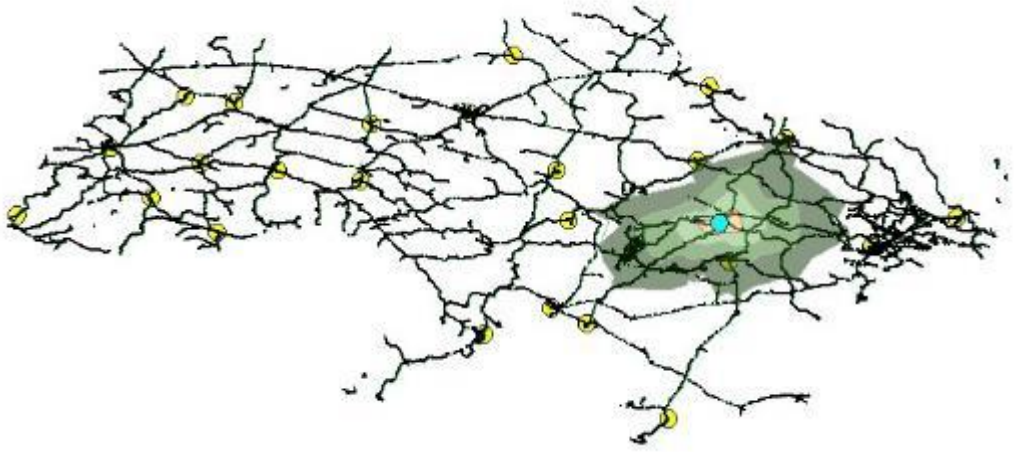


Figure 2.59

It is established that during the modeling of the route network for passenger transportation in relation to the selected transport node the realization of passenger route transport correspondence is provided. Certain correspondences can be realized between the center of the constructed landfill and three other nodes only if you drive for up to 8 hours.

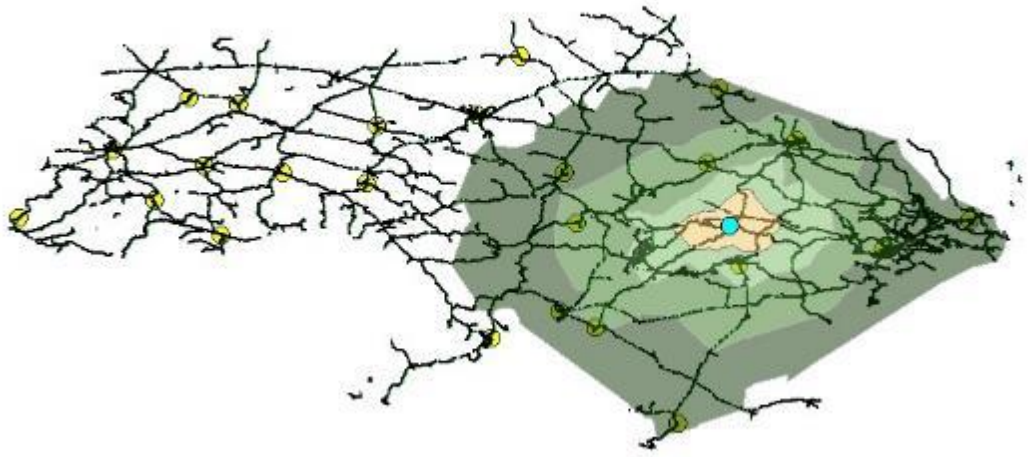


Figure 2.60

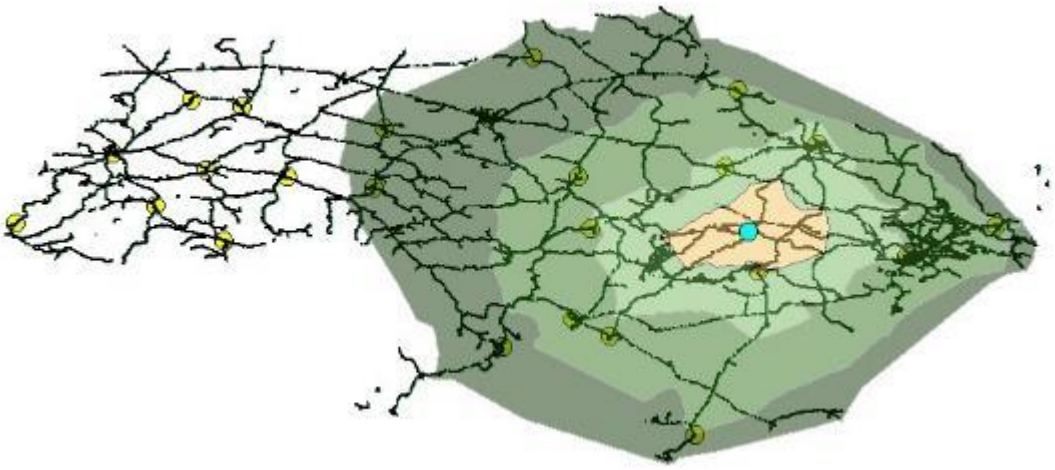


Figure 2.61

It is established that during the modeling of the route network for passenger transportation relative to the selected transport node, the implementation of passenger route transport correspondence is provided [42–45]. If passengers keep the set parameters of modeling landfills for maximum route transport accessibility, it is established that within 1.5 hours of driving the landfill contains only one node, except for the landfill construction center. When considering the landfill, which corresponds to transport accessibility when driving within 1.5 to 3 hours, you can reach four transport hubs. In the case of the organization of scheduled transportation with the definition of the average speed of 98 km / h and driving time from 3 to 5 hours from the center of the constructed landfill can reach up to seven nodes; up to six knots can be reached in 5 to 8 hours. Comparing Figures 2.58 and 2.

The model of landfills was implemented using the model of the road network, which, unlike the previous ones, is a combination of road and railway networks. Figure 2.62 shows the same model of landfills for maximum passenger route transport accessibility in the integrated road network [46].

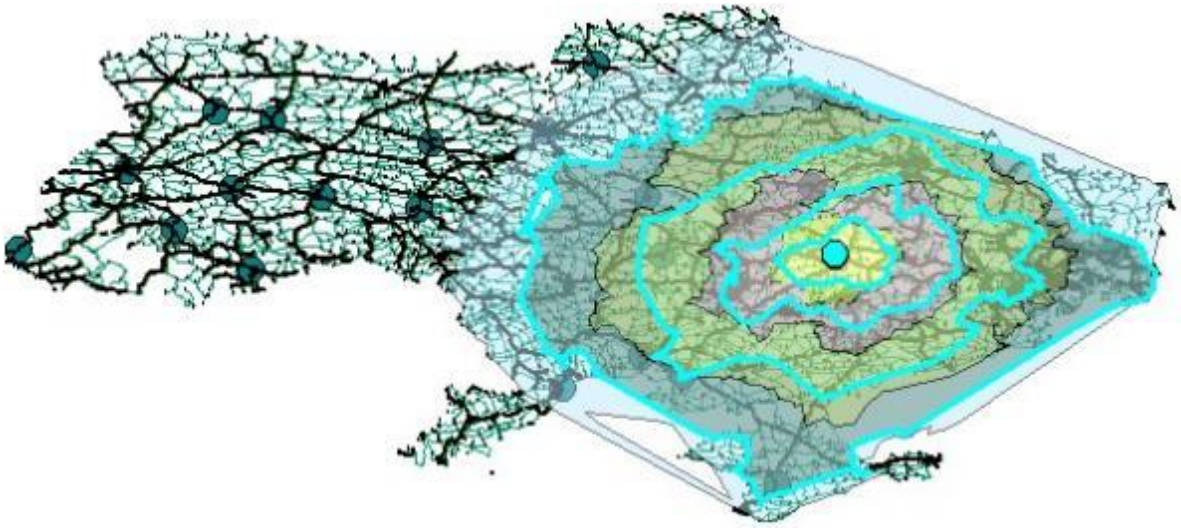


Figure 2.62

The results of modeling the parameters of route accessibility of transportation were studied in both road networks simultaneously. It was found that within a 1.5-hour drive, the railway test site at a speed of 68 km / h does not reach any nodes (cities) in both networks, and the road test site with the same speed contains one node (city). The landfill built on railways when driving within 1.5 to 3 hours contains one transport node, and the road in these conditions - two. During the examination of the landfill, which corresponds to the transport accessibility by rail within a ride of 5 to 8 hours, it was found that it contains eleven transport nodes, and the road in these conditions - thirteen. Comparing rail and road transport accessibility, we can conclude that

The strengths of the study can be considered that the obtained landfills were modeled with geographical accuracy, the results of simultaneous operation of railway and road networks. In contrast to the previously proposed approaches to solving the problems of planning the indicators of the transport process by means of network analysis, a comprehensive approach with the use of the latest information technologies is proposed.

The disadvantage of the study can be considered the lack of consideration of changes in the total travel time in the event of changes in the networks through which transportation is carried out. However, the proposed approach determines that it is

possible to provide such conditions under which the transport accessibility of the networks when using both networks in one ride will be maximum. Failure to take into account the increase in driving time when changing networks may lead to a decrease in the average driving speed, which will be the basis for reducing the identified landfill.

The proposed study can be obtained in particular regarding the planning of time and energy resources used in the transportation process.

The disadvantages of the proposed method of planning parameters are the disregard for the characteristics of each arc of the studied network. Probably, the reason was that the speed not used on some sections of railways and highways was used to determine the landfills to calculate the speed of movement. This led to the receipt of settlement landfills with unrealistic characteristics.

2.3 Determination of the density of the transport network

Provided that passengers have the opportunity to meet the needs for movement in the most convenient way, it is possible to realize the maximum potential transport correspondence between the nodes of the transport network. The basic factors that affect the actual volume of passenger traffic between the nodes of the transport network can be considered:

- potential correspondence;
- fare;
- driving time;
- time of day of the ride;
- riding comfort;
- regularity and frequency of driving;
- social and economic characteristics of regional development in transport hubs.

It should be noted that the actual indicators of passenger traffic should be adjusted to take into account the characteristic seasonal or daily fluctuations.

According to the results of the analysis, it is established that today the issue of determining the impact of road network parameters on the economic and social condition of the regions is insufficiently studied. The issue of determining the quality of the road network design and the compliance of the available drawings with the optimal ones has not been fully studied.

To determine the efficiency of road networks, the impact of road network development on social and economic indicators, it is proposed to use methods of systems analysis. The actual state of development of road networks with the congestion of geographic information systems was studied on the example of the road network of Ukraine.

The author of [38, 47] considers the density of the road network as a basic indicator. It is proposed to determine the total public costs of transportation by dependence (2.1).

$$C_{пг} H T^{зв} + C_{б} \delta F_{с} = Z \rightarrow \min, \qquad (2.1)$$

where $C_{пг}$ - cost of an hour of transport time, UAH / hour;

Z - total public transportation costs, UAH;

H - number of rides per year, units;

$C_{б}$- cost of construction and operation of one kilometer of road network, UAH;

δ - density of the transport network, 1 / km;

$F_{с}$ - residential area of the city, km2;

$T^{зв}$- consolidated travel time of medium distance, h.

Thus, it is clear that the state of the road network affects the density and the combined travel time of medium distances.

The combined time of a medium-distance trip undoubtedly depends on the length of the medium-distance trip, which, in turn, is determined by the peculiarities of the road network pattern.

Under such conditions, it is fair to say that the optimal cumulative travel time for medium-distance travel is the minimum time. It is possible to minimize the reduced

travel time of a medium distance by increasing the driving speed or reducing its distance [48-52].

Driving speed is a quantitative reflection of the complex interaction of a set of factors, namely: the technical capabilities of the vehicle, road characteristics, the number and features of stops and more. You can reduce the riding distance by determining the shortest riding route. Graph theory is mostly used when planning variants of route schemes using modern mathematical approaches [53-56].

We calculate the transport development of the territory with paved roads on the example of Kharkiv.

Preparing the display Steps:

1. Open the network dataset set file.
2. In the ArcMap - Getting Started dialog box, click Existing Maps> Browse for more.
3. Navigate to the C: \ ArcGIS \ ArcTutor \ ArcGIS Network Analyst \ Tutorial \ KharkivTransportation folder.
4. This default location is for setting up learning materials. Double-click the Kharkiv.mxd file. The map document will open in ArcMap (Fig. 2.63).

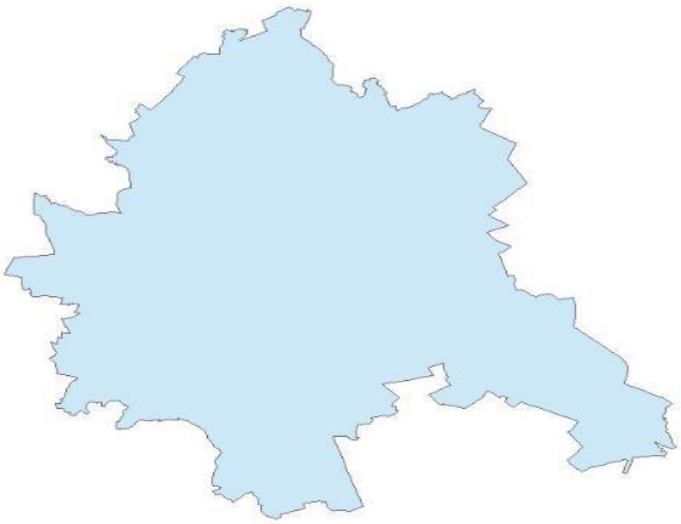


Figure 2.63

5. Activate the ArcGIS Network Analyst plug-in by running the following actions:

a) click on Settings (Customize)> Additional modules (Extensions). The Extensions dialog box opens;

b) mark ArcGIS Network Analyst;

c) click Close.

If the Network Analyst toolbar doesn't appear, you'll need to add it.

6. Click Customize> Toolbars> Network Analyst.

The Network Analyst toolbar will be added to ArcMap (Figure 2.64).

Figure 2.64

If the Network Analyst window does not appear, you need to add it.

On the Network Analyst toolbar, click the Network Analyst window. The attached Network Analyst window will open (Fig. 2.65).

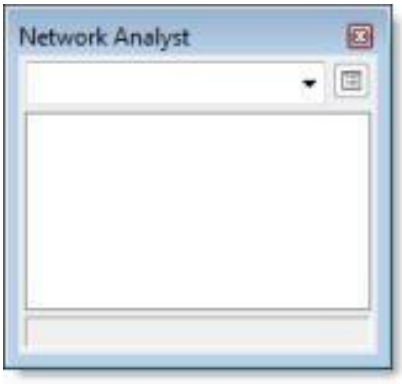


Figure 2.65

The Network Analyst window can be pinned and unpinned.

Construction of hexagons throughout Kharkiv

To build hexagons, use the Generate Pattern of Repeating Shapes tool. Steps:

1. Click the Generate Pattern of Repeating Shapes button contained on the main toolbar.

The Generate Pattern of Repeating Shapes tool dialog box opens (Figure 2.66).

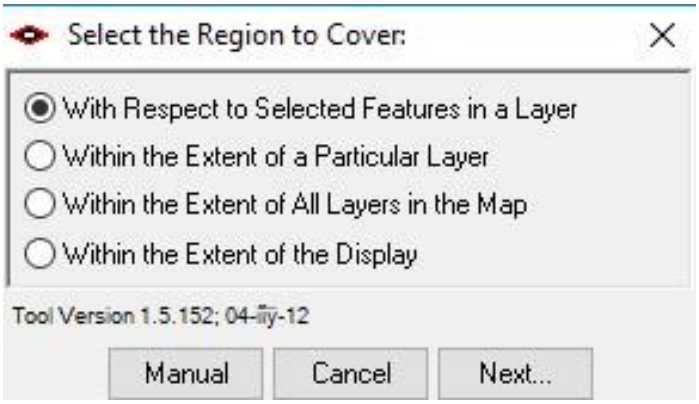


Figure 2.66

2. Click Next.
3. Select the Kharkiv polygon where the hexagons will be created.
4. Select Use all records.
5. Click OK.
6. Choose the value of the hexagons Hexagons.
7. Click Next.

Hexagon Parameters opens.

8. In the Area area, enter a value of 10,000,000.

The value of 10,000,000 m2 (10 km2) is the area of each hexagon.

9. In the Output Feature Class or Shapefile value, select the path to save the shape file named Hexagons (Fig. 2.67).

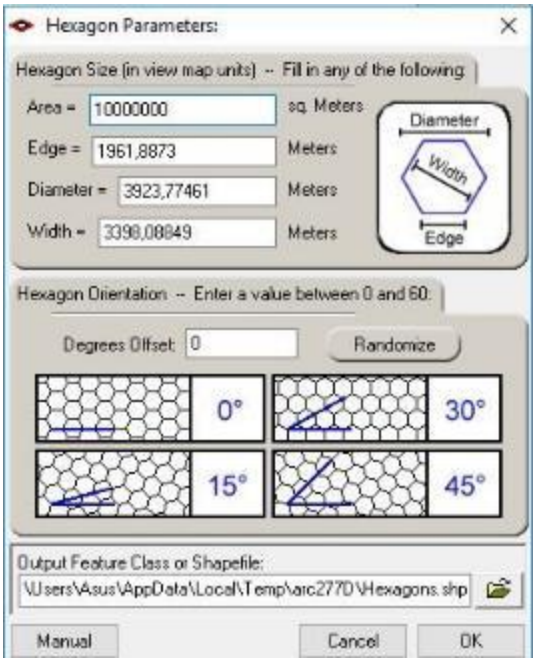


Figure 2.67

10. Click OK.

11. A dialog box opens, click the Exit button.

A layer of hexagons has been added to the map and Table of Contents window (Figs. 2.68, 2.69).

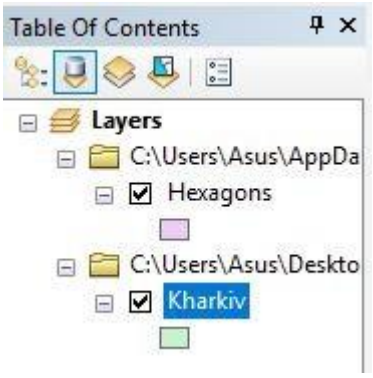


Figure 2.68

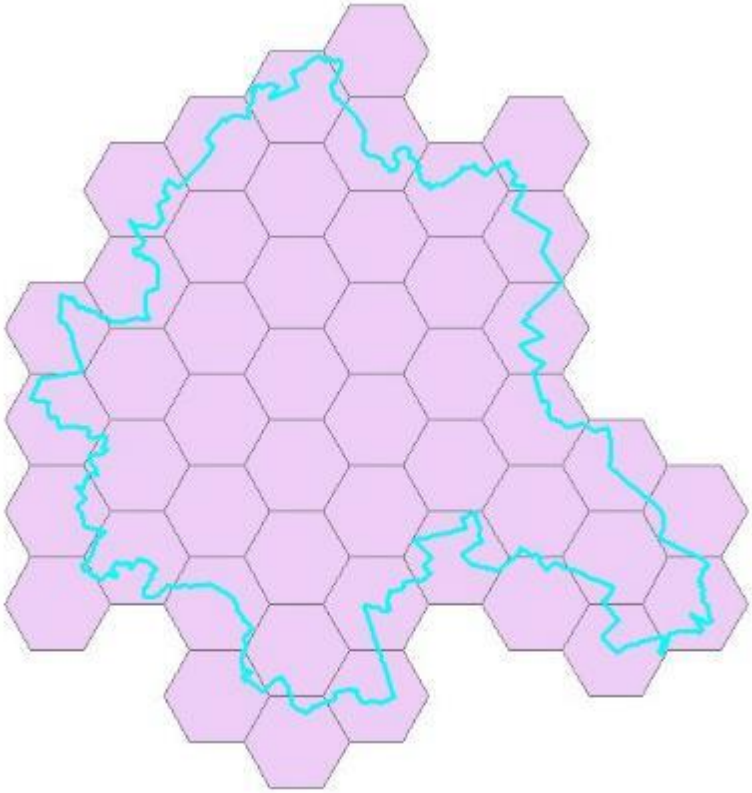


Figure 2.69

Editing hexagons

Use the Clip tool to cut hexagons along the Kharkiv border.

Steps:

1. Click the Geoprocessing button on the main toolbar.
2. Select the Clip tool.

The Clip dialog box opens.

3. In the Input Features field, select Hexagons.
4. In the Clip Features field, select Kharkiv.
5. In the Output Future Class field, set the save mode and name the shape file Clip (Fig. 2.70).

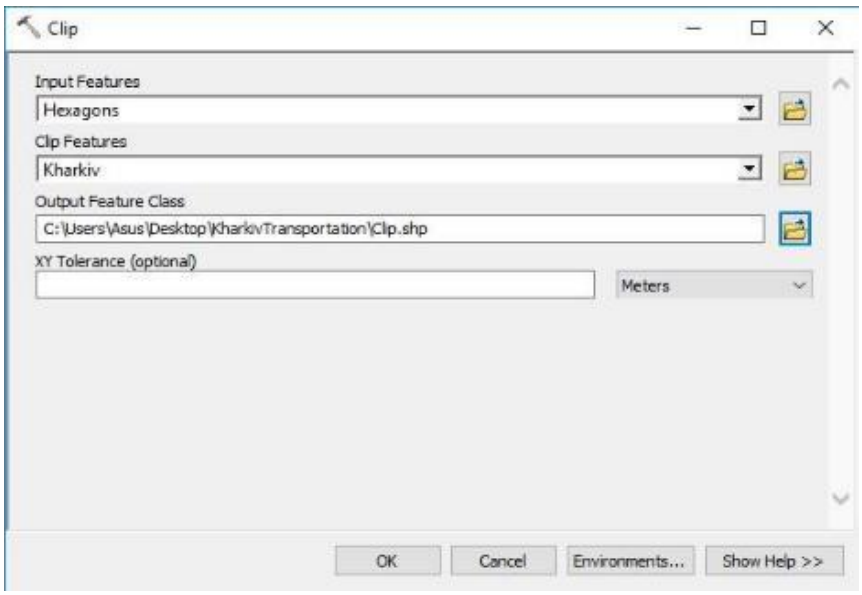


Figure 2.70

6. Click OK.

7. Remove layers of Hexagons and Kharkiv landfill from Table of Contents.

With the help of the Clip tool, hexagons along the Kharkiv border were edited, and a new shape file called Clip was added for further work (Figs. 2.71, 2.72).

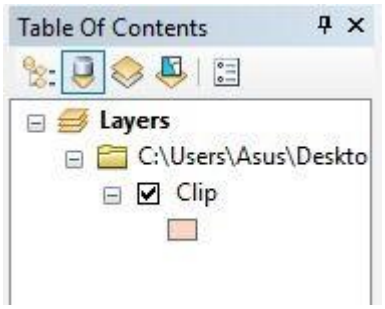


Figure 2.71

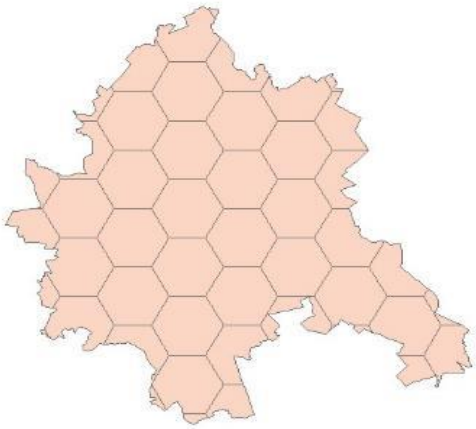


Figure 2.72

8. Right-click the Clip file and open the attribute table.
9. Click the Table Options button and select the Add Field function.
10. In the Name field, enter the name Area.
11. In the Type field, select Double.
12. Click OK.

Add a column in the table of attributes called Area (Fig. 2.73).

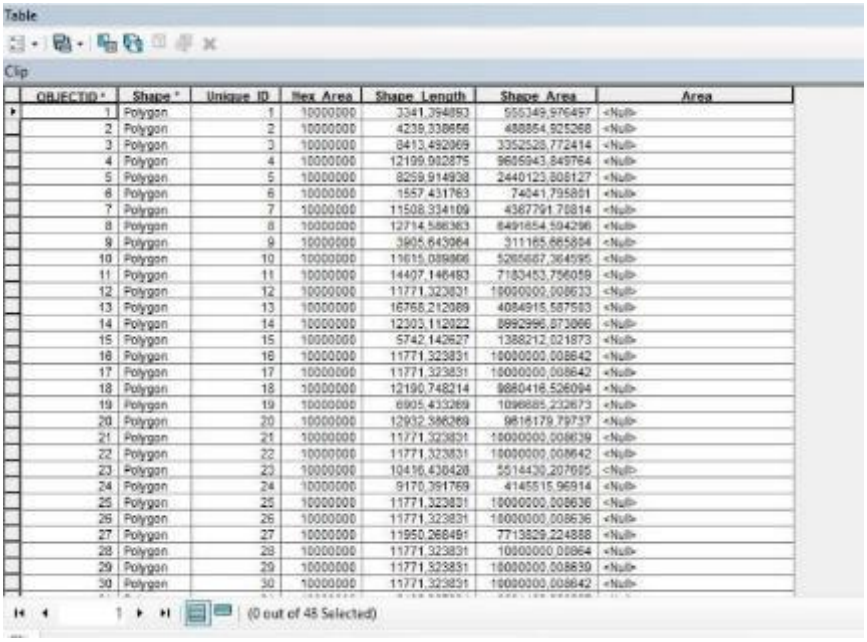


Figure 2.73

13. Left-click on the Area column to select the entire column.
14. Right-click on the Area column and select Field Calculator.
15. Click Yes.

The Field Calculator dialog box opens.

16. In the Fields window, double-click Shape_Area to add this column to the Area = window (Figure 2.74).

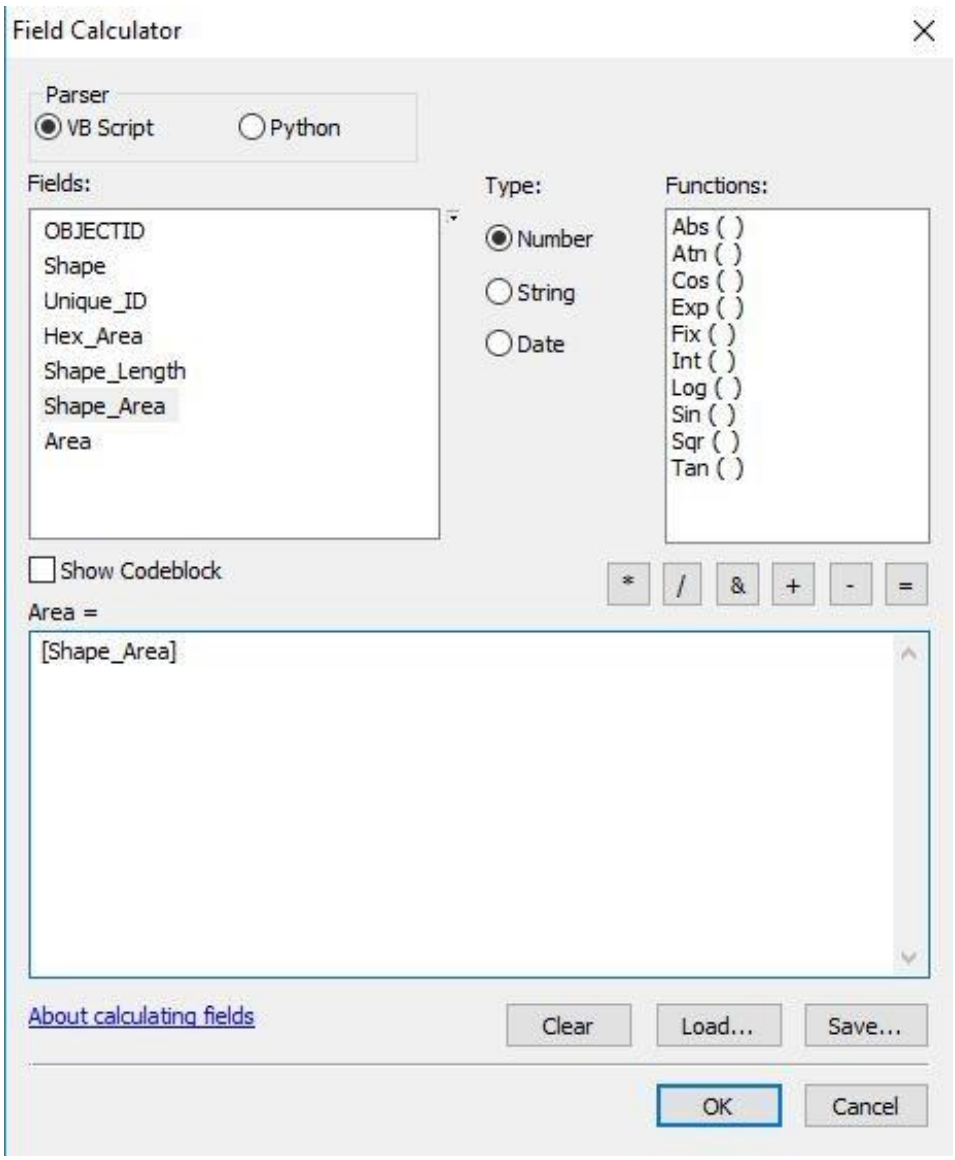
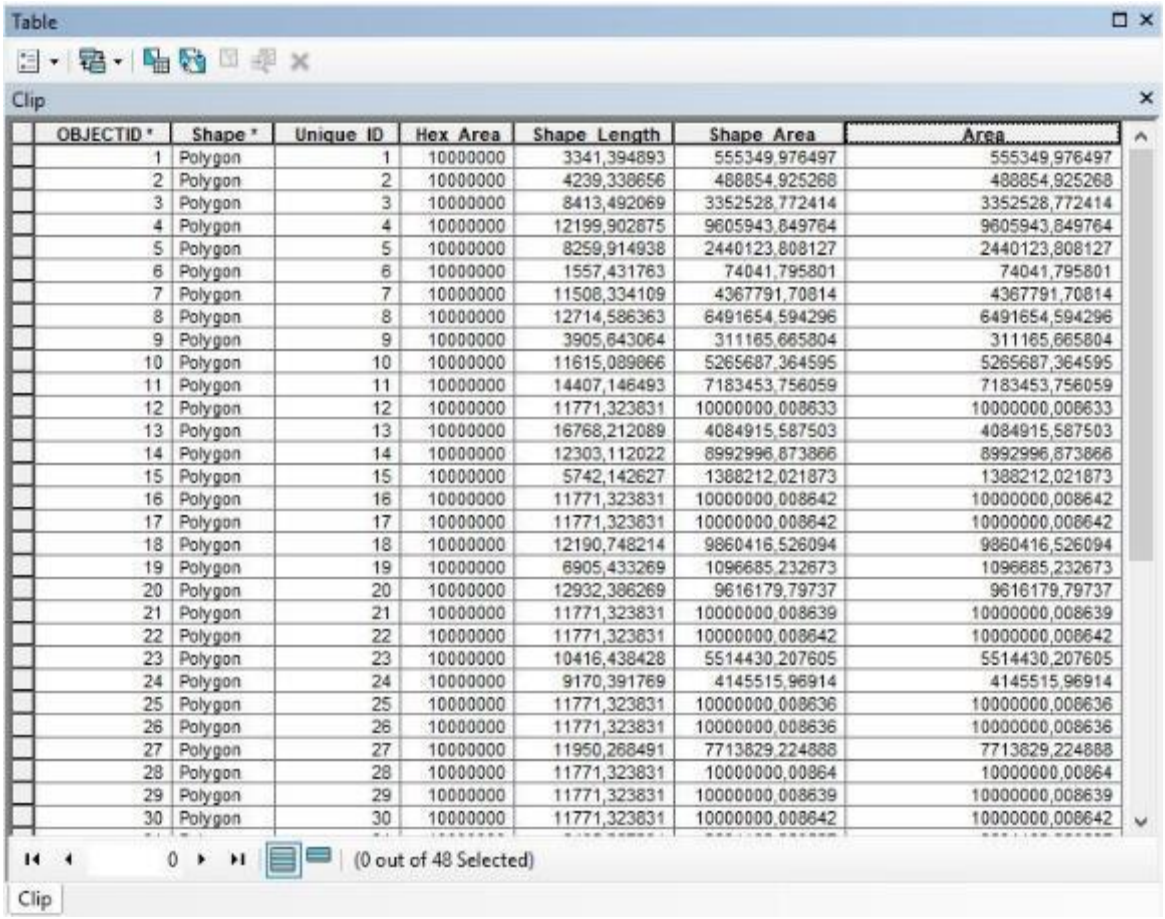


Figure 2.74

17. Click OK.

Using the Field Calculator function, the area of each hexagon in the Double type was calculated (Fig. 2.75).



OBJECTID *	Shape *	Unique_ID	Hex_Area	Shape_Length	Shape_Area	Area
1	Polygon	1	10000000	3341,394893	555349,976497	555349,976497
2	Polygon	2	10000000	4239,338656	488854,925268	488854,925268
3	Polygon	3	10000000	8413,492069	3352528,772414	3352528,772414
4	Polygon	4	10000000	12199,902875	9605943,849764	9605943,849764
5	Polygon	5	10000000	8259,914938	2440123,808127	2440123,808127
6	Polygon	6	10000000	1557,431763	74041,795801	74041,795801
7	Polygon	7	10000000	11508,334109	4367791,70814	4367791,70814
8	Polygon	8	10000000	12714,586363	6491654,594296	6491654,594296
9	Polygon	9	10000000	3905,643064	311165,665804	311165,665804
10	Polygon	10	10000000	11615,089866	5265687,364595	5265687,364595
11	Polygon	11	10000000	14407,146493	7183453,756059	7183453,756059
12	Polygon	12	10000000	11771,323631	10000000,008633	10000000,008633
13	Polygon	13	10000000	16768,212089	4084915,587503	4084915,587503
14	Polygon	14	10000000	12303,112022	8992996,873866	8992996,873866
15	Polygon	15	10000000	5742,142627	1388212,021873	1388212,021873
16	Polygon	16	10000000	11771,323631	10000000,008642	10000000,008642
17	Polygon	17	10000000	11771,323631	10000000,008642	10000000,008642
18	Polygon	18	10000000	12190,748214	9860416,526094	9860416,526094
19	Polygon	19	10000000	6905,433269	1096685,232673	1096685,232673
20	Polygon	20	10000000	12932,386269	9616179,79737	9616179,79737
21	Polygon	21	10000000	11771,323631	10000000,008639	10000000,008639
22	Polygon	22	10000000	11771,323631	10000000,008642	10000000,008642
23	Polygon	23	10000000	10416,438428	5514430,207605	5514430,207605
24	Polygon	24	10000000	9170,391769	4145515,96914	4145515,96914
25	Polygon	25	10000000	11771,323631	10000000,008636	10000000,008636
26	Polygon	26	10000000	11771,323631	10000000,008636	10000000,008636
27	Polygon	27	10000000	11950,268491	7713829,224888	7713829,224888
28	Polygon	28	10000000	11771,323631	10000000,00864	10000000,00864
29	Polygon	29	10000000	11771,323631	10000000,008639	10000000,008639
30	Polygon	30	10000000	11771,323631	10000000,008642	10000000,008642

Figure 2.75

Intersection of highways with a layer of hexagons To get started, you'll need to add a layer of roads to the map.

Steps:

1. Click the Add Data button (Fig. 2.76).

Figure 2.76

2. Select the folder KharkivTransportation / Kharkiv.gdb, which contains the shape file of streets (streets Kharkiv) and double-click on it.

A shape file of the street has been added to the map of Kharkiv (Fig. 2.77).

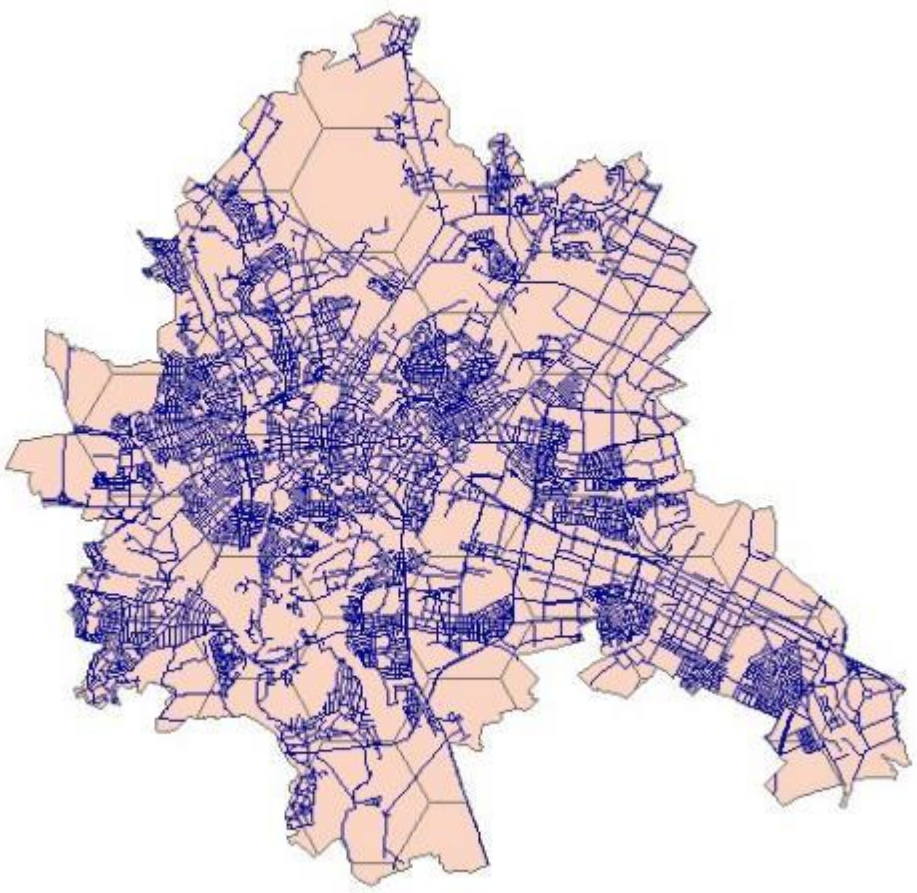


Figure 2.77

Use the Intersect tool to assign each hexagon number where it is located.

3. Click the Geoprocessing button on the main toolbar.

4. Select the Intersect tool.

The Intersect dialog box opens.

5. In the Input Features field, select StreetsKharkiv and Clip.

6. In the Output Features Class field, set the way to save a new shapefile file called inter_Kharkiv_hard to the Kharkiv.gdb file database (Fig. 2.78).

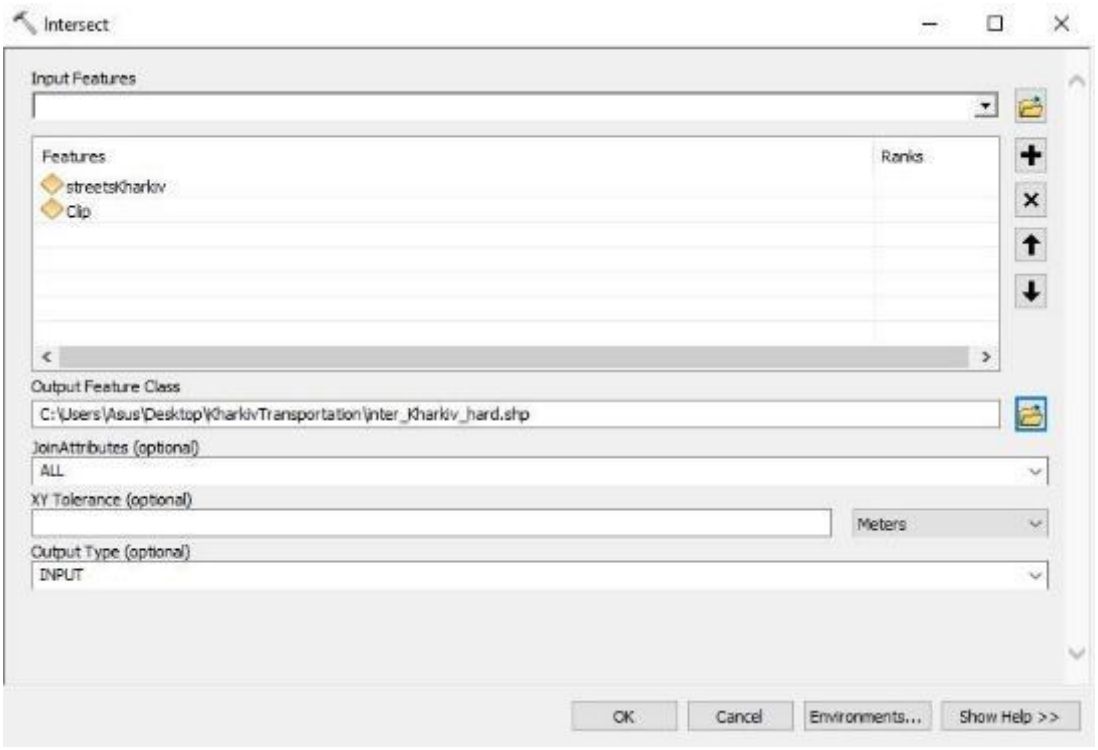


Figure 2.78

7. Click OK.

Added a new shapefile named inter_Kharkiv_hard.

8. Open the attribute table of the inter_Kharkiv_hard shapefile (Fig. 2.79).

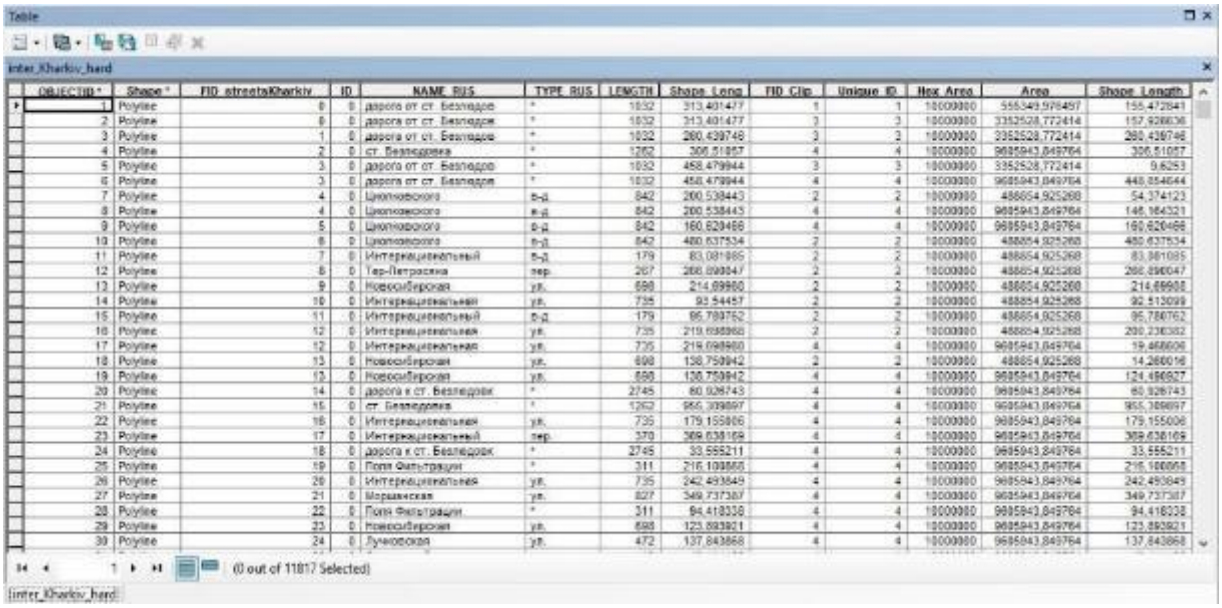


Figure 2.79

This table contains information about the name of the road (Name), the type of road (Type), the hexagon in which it is located (Unique_ID), the area of the hexagon (Area), and so on.

Determination of the number, sum of road lengths and density coefficients in each hexagon

Use the Summary Statistics tool to calculate the sum of the length, the number of roads, and the density factor in each hexagon.

Steps:

1. Click the ArcToollbox button. A set of tools opens (Fig. 2.80).

Figure 2.80

2. Double-click Analysis Tools.
3. Double-click Statistics.
4. Select the Summary Statistics tool.

The Summary Statistics tool dialog box opens.

5. In the Input Table field, select the inter_Kharkiv_hard shapefile.

6. In the Output Table field, specify how to save the file to the Kharkiv.gdb database called inter_Kharkiv_hard_Statistics.

7. In the Statistics Field (s) field, select Shape_leng.

8. In the Statistic Type column, select SUM.

9. In the Case Field (optional) column, select the Unique_ID and Area values (Figure 2.81).

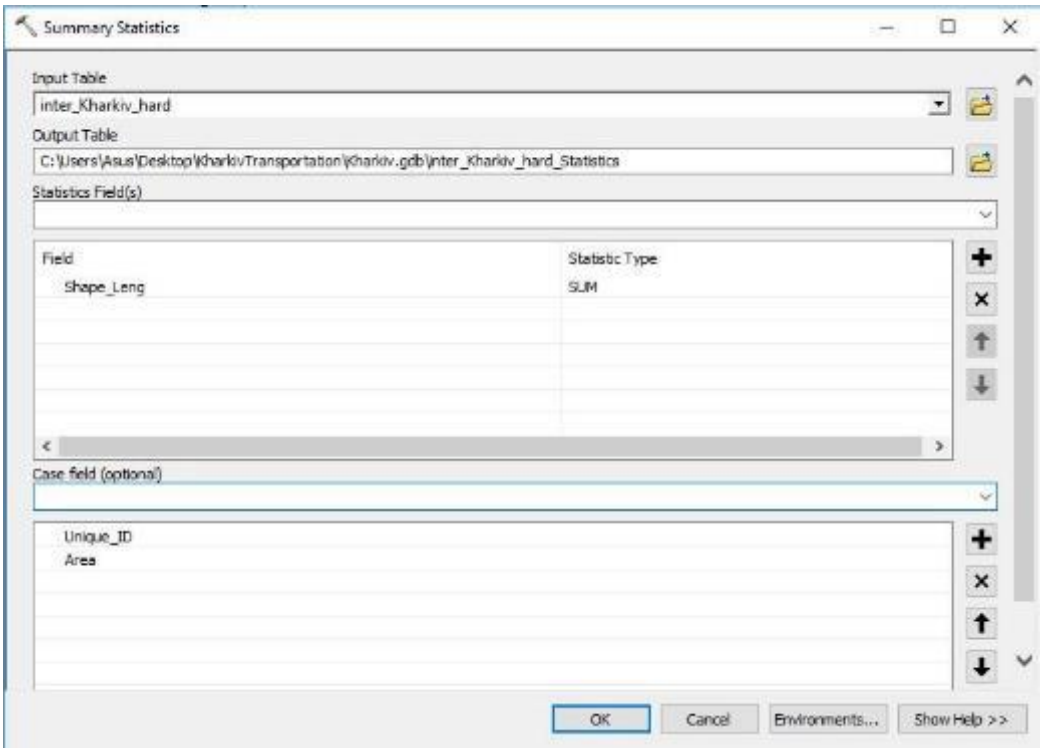


Figure 2.81

10. Click OK.

11. Close the ArcToolbox.

Added a table called inter_Kharkiv_hard_Statistics, in which the column FREQUENCY is the number of roads in each hexagon, SUM_Shape_Leng is the sum of the lengths of the roads in each hexagon, Area is the area of each hexagon.

12. Click the Table Options button and select the Add Field function.

13. In the Name field, enter the name Plot_tr_set.

14. In the Type field, select Double.

15. Click OK.

16. Left-click on Plot_tr_set to select the entire column.

17. First click on the Plot_tr_set column and select Field Calculator.

18. Click Yes.

The Field Calculator dialog box opens.

19. In the Fields window, double-click SUM_Shape_Leng to add this column to the Plot_tr_set = window.

20. In the Plot_tr_set window, add a delimiter.

21. In the Fields window, double-click Area to add this column to the Plot_tr_set = window (Figure 2.82).

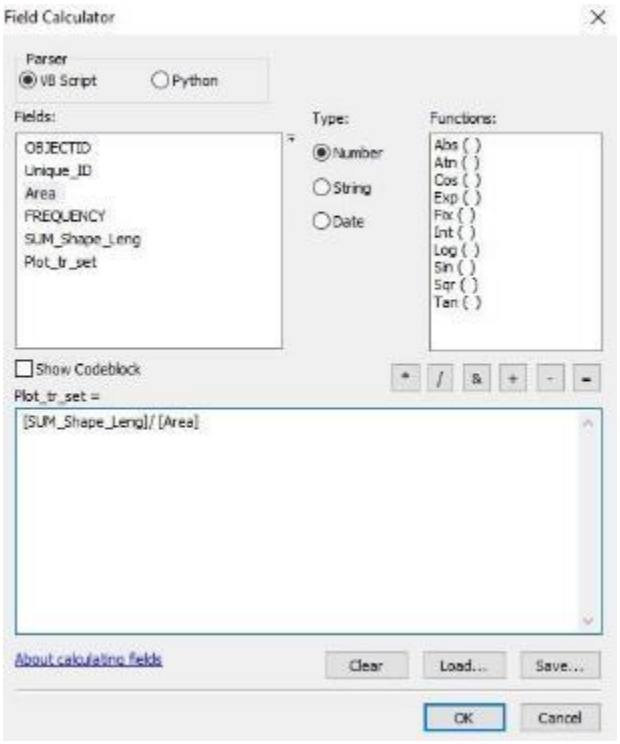


Figure 2.82

22. Click OK.

Added column Plot_tr_set, which contains the coefficient of road density in each hexagon (Fig. 2.83).

OBJECTID *	Unique_ID	area	FREQUENCY	SUM_Shape_Leng	Plot_tr_set
1	1	555349,984392	1	313,401477	0,000564
2	2	488854,955937	10	1904,265044	0,003895
3	3	3352528,703809	4	4677,483533	0,001395
4	4	9605943,797842	127	29230,159125	0,003043
5	5	2440123,803238	39	8294,104533	0,003399
6	6	74041,77345	2	560,909597	0,007576
7	7	4367791,798454	112	25485,965108	0,005835
8	8	6491654,772378	75	24734,067982	0,00381
9	9	311165,711029	39	5806,585023	0,018661
10	10	5265687,472058	54	20379,718154	0,00387
11	11	7183453,764039	284	51509,65933	0,007171
12	12	10000000,000015	422	72510,62617	0,007251
13	13	4084915,595037	79	17456,414575	0,004273
14	14	8992996,727005	490	88732,95013	0,009867
15	15	1388211,974915	141	20172,914588	0,014532
16	16	10000000,000001	387	62630,417068	0,006263
17	17	9999999,999994	425	74694,98447	0,007469
18	18	9860416,556821	486	91645,718406	0,009294
19	19	1096685,200857	41	10959,89368	0,009994
20	20	9616179,757221	279	55290,007398	0,00575
21	21	9999999,999998	549	82524,190453	0,008252
22	22	9999999,999998	420	77149,292489	0,007715
23	23	5514430,175245	31	15416,995726	0,002796
24	24	4145515,940814	55	11649,592749	0,00281
25	25	9999999,999995	960	123961,459176	0,012396
26	26	9999999,999989	404	65886,367667	0,006589
27	27	7713829,170992	279	46255,724383	0,005996
28	28	10000000,000004	643	89969,786451	0,008997
29	29	10000000,000004	704	106048,294763	0,010605
30	30	10000000,000004	690	104962,776244	0,010496
31	31	2631182,204676	10	4817,492871	0,001831
32	32	10000000,000001	688	103058,521374	0,010306
33	33	9999999,999994	785	112630,260803	0,011263

Figure 2.83

2.4 Conclusions by section

The strengths of this study include the ability to apply a certain coefficient of straightness of the road network when assessing the location of production sites, which will minimize the transport component in the final cost of production, and thus lead to positive socio-economic consequences. New information on the characteristics of the road network of Ukraine was obtained [57].

The shortcomings of the study and the results obtained can be considered the inability to take into account the fact of the existing railway network in Ukraine. However, it should be noted that the purpose of this work was to determine the impact of the road network pattern on the basic indicators of the transport process. Taking into account the fact that highways are more common than railways, we can assume that the goals of the work have been achieved [42, 58-59]. The study also considered the options for the shortest connection of transport hubs, which can be further

implemented, taking into account the possibility of travel on all roads. This way you can set the shortest routes, which are always the fastest. It should be noted

Accurately calculated value of the coefficient of straightness of the road network makes it possible to plan the development of transport infrastructure and meet the needs of the population for transportation within the research system. At the same time, it is possible to improve the quality of financial flows of production by optimizing the allocation of resources [60-63].

There are also difficulties associated with the application of the results of the study. This applies to the processes of optimizing the selected model of the road network by introducing additional arcs in it. It is proposed to implement the need to move between the nodes of the network on the shortest connection, which can lead to the use of network arcs with relatively low connection speeds and increase the total driving time.

3 ROUTE MODELING

3.1 Construction and analysis of the route model

This section describes the process of creating a model to determine the shortest route connecting the 25 transport hubs of Kharkiv.

Steps:

1. Activate the ArcGIS Network Analyst plug-in by following these steps:

a) click on Settings (Customize)> Additional modules (Extensions). The Extensions dialog box opens;

b) mark ArcGIS Network Analyst;

c) click Close.

If the Network Analyst toolbar doesn't appear, you'll need to add it.

2. Click Customize> Toolbars> Network Analyst.

The Network Analyst toolbar will be added to ArcMap (Figure 3.1).

Figure 3.1

If the Network Analyst window does not appear, you need to add it.

3. On the Network Analyst toolbar, click the Network Analyst window. The attached Network Analyst window will open (Fig. 3.2).

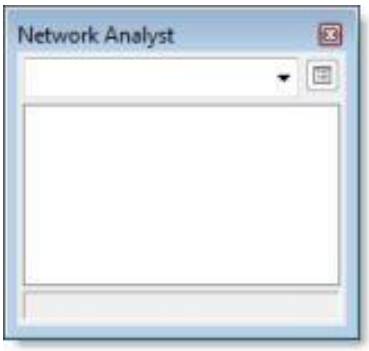


Figure 3.2

The Network Analyst window can be pinned and unpinned.

Creating a model Steps:

1. Click the Catalog window button Standard toolbars.

The Catalog window opens.

In the Catalog window, expand the Toolboxes node.

2. Click right button mouse on items My Toolboxes and select the command New (New)> Toolbox (Toolbox) (Fig. 3.3).

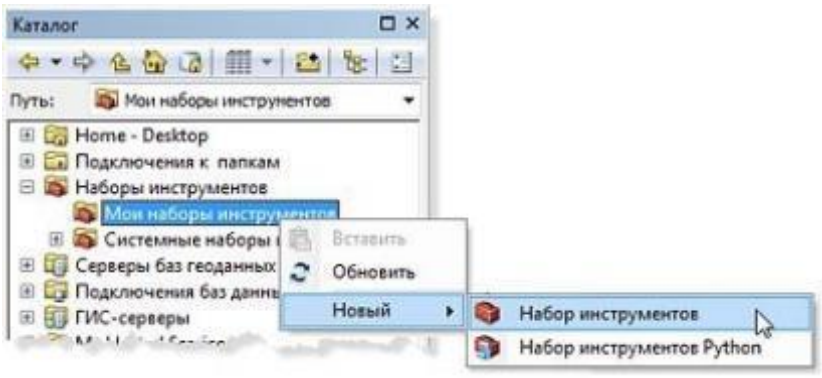


Figure 3.3

3. Enter the Network Model and click ENTER to name the added toolkit.

4. Right-click the Network Model toolkit and choose New> Model.

The new model will appear in the toolkit and open the Model dialog box (Fig. 3.4, 3.5).

Figure 3.4

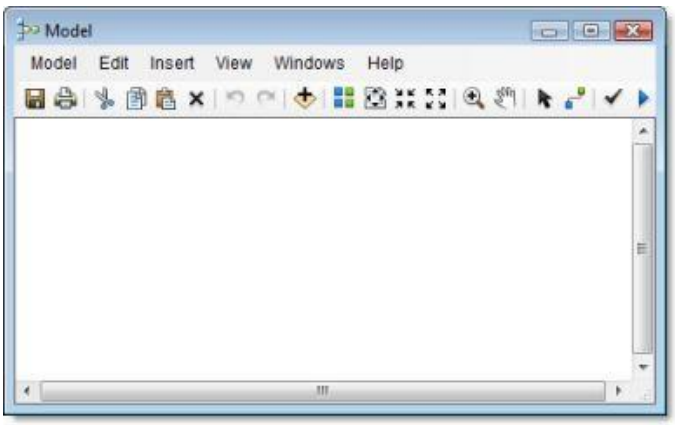


Figure 3.5

Creating a route layer in the model

Next, a route layer will be created in the model. The process of using the ArcGIS Network Analyst plug-in in the model coincides with the process of using the Network Analyst in ArcMap. First you need to create a route layer and set the properties. Next you need to add network locations (stops), which will be the input data and display the results.

Steps:

1. IN menu click on Geoprocessing (Geoprocessing)> Search For Tools. The attached Search window will open, in which the Tools category is highlighted (Fig. 3.6).

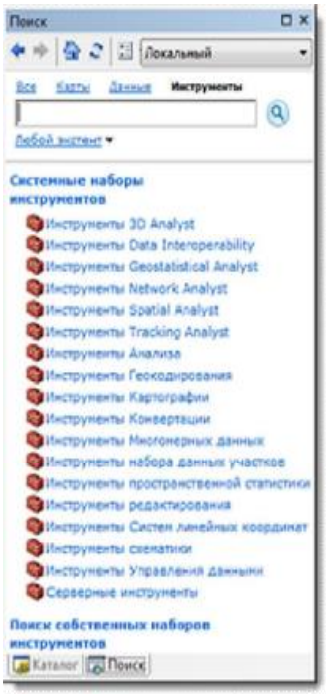


Figure 3.6

2. Click Network Analyst Tools from the list of toolkits in the Search window.

A list of tool groups and tools related to the ArcGIS Network Analyst plug-in appears.

3. Click Analysis in the Search section of the Search window.

The Search window displays only tools related to network analysis.

4. Drag the Make Route link Layer in the Model dialog box (Fig. 3.7).

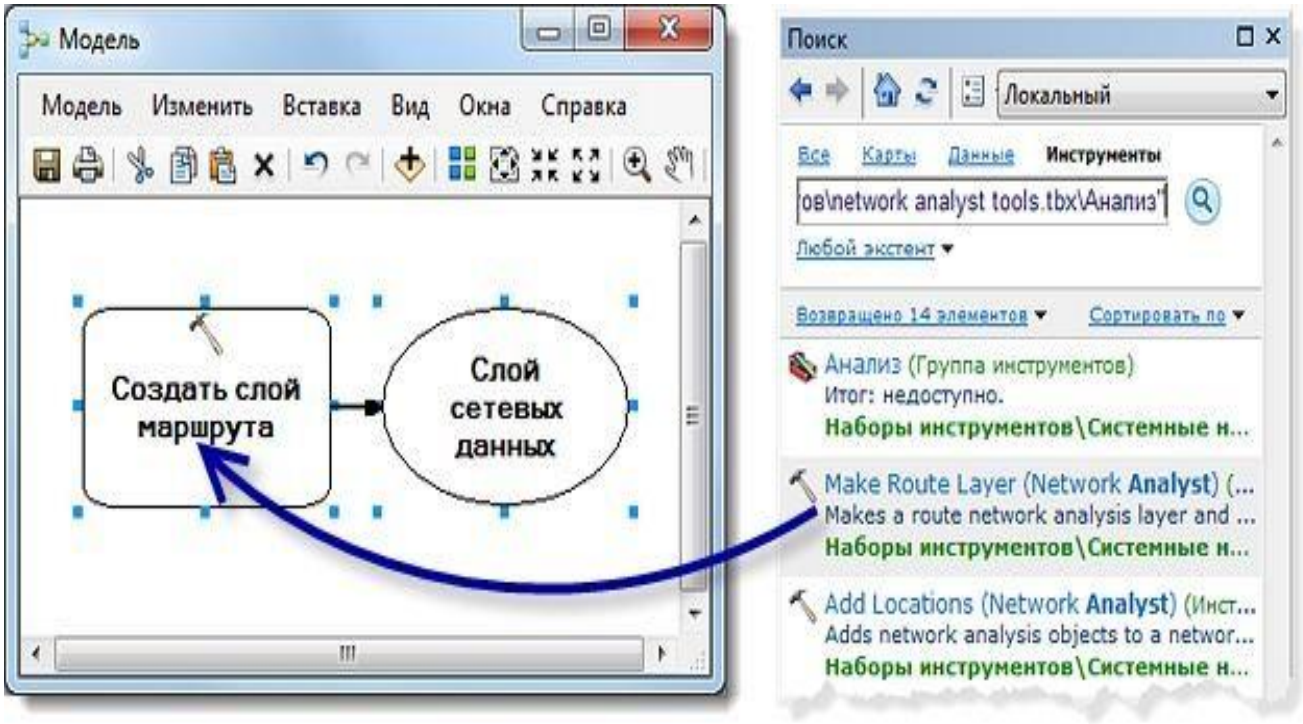


Figure 3.7

5. In the Model dialog box, double-click Make Route Layer.

The Make Route Layer dialog box opens, where you can set properties.

6. From the Input analysis network list, select Streets_ND.

7. In the Impedance attribute list, click Drive Time.

8. Check the box next to Reorder stops to find optimal route.

1. From the Preserve ordering of stops list, click PRESERVE_BOTH.

The tool dialog box should look like this (Fig. 3.8).

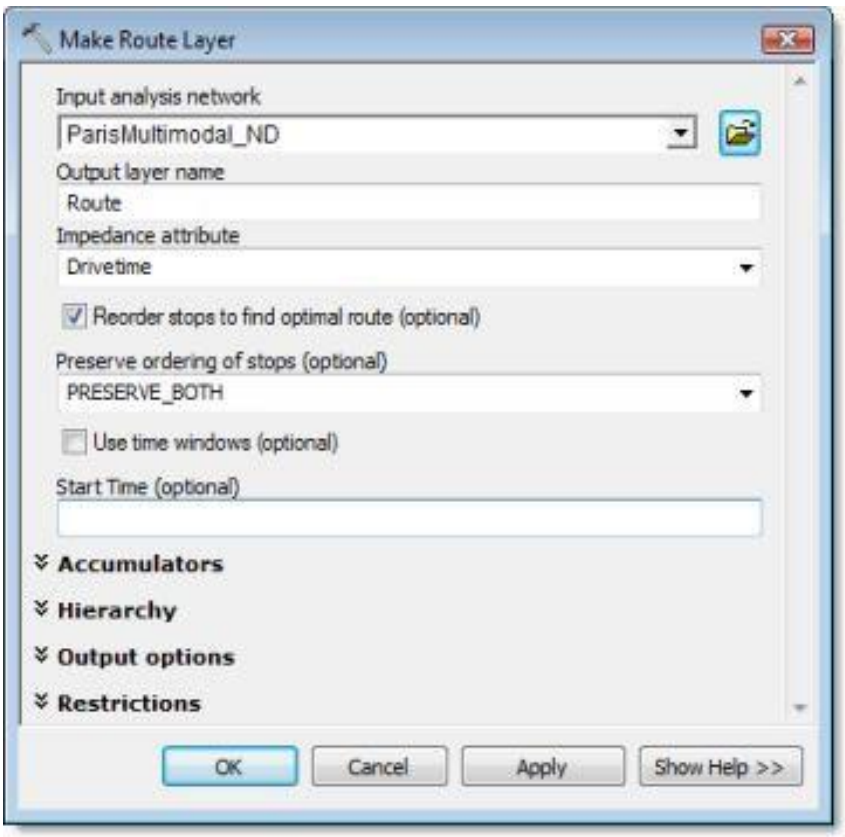


Figure 3.8

2. Click OK.

The input analysis layer is added to the model. The Make Route Layer turns yellow and the result turns green.

3. Click the Full View> Full View button. The entire model will be displayed.

Add stops to the route layer

Next, stores will be added as stops using the Add Locations tool.

Steps:

1. Drag the Add Locations tool from the Search window to the Model dialog box (Figure 3.9).

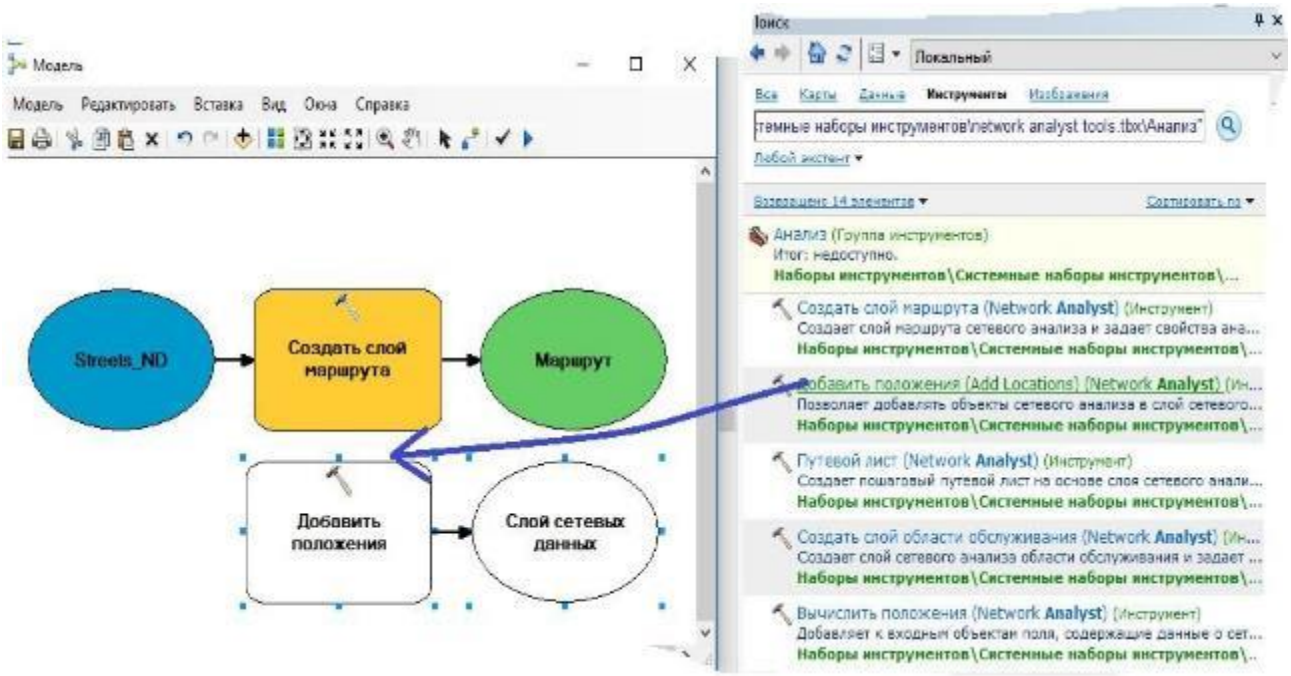


Figure 3.9

2. Select the Transports functional layer in the Table Of Contents window and drag it to the model to the left of the Add Locations tool (Figure 3.10).

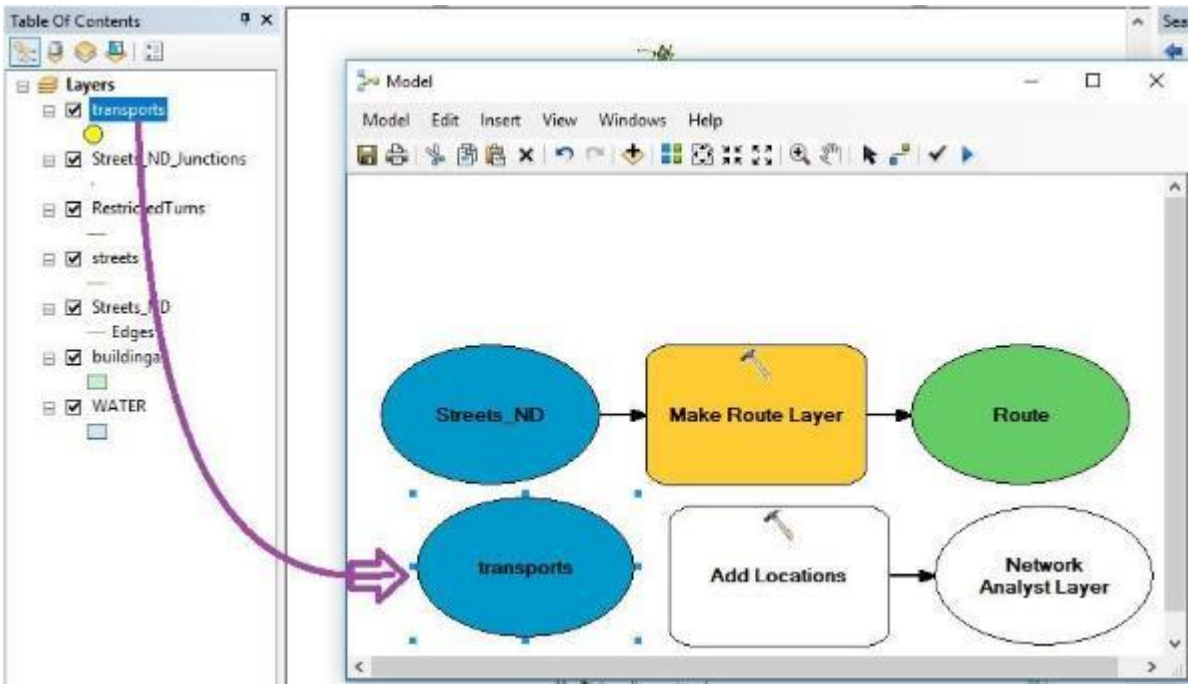


Figure 3.10

3. In the Model dialog box, select the Connect Connection tool.

4. Click on Transports and Add Locations to connect to them. In the context menu, click on Input locations (Fig. 3.11).

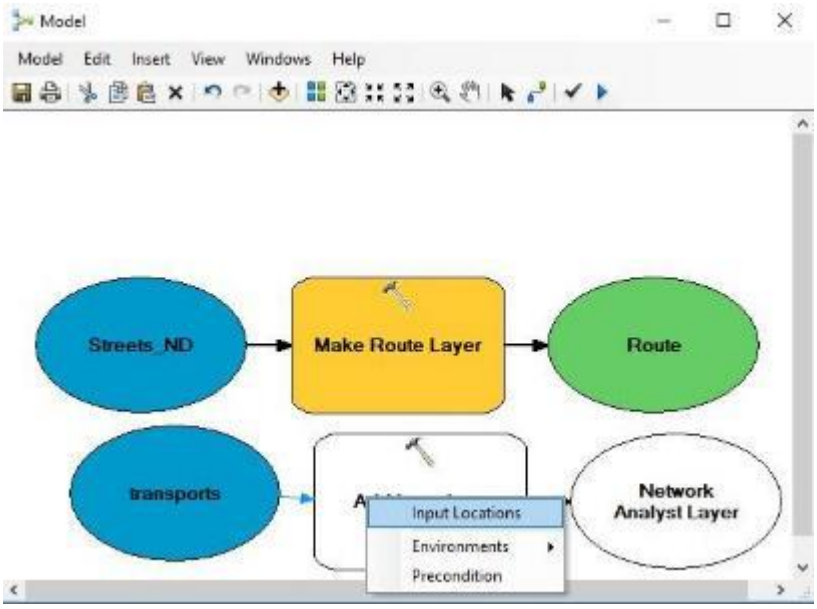


Figure 3.11

5. Using the Connect tool, select Route to the Add Locations tool. In the context menu, click on the Input network analysis layer (Fig. 3.12).

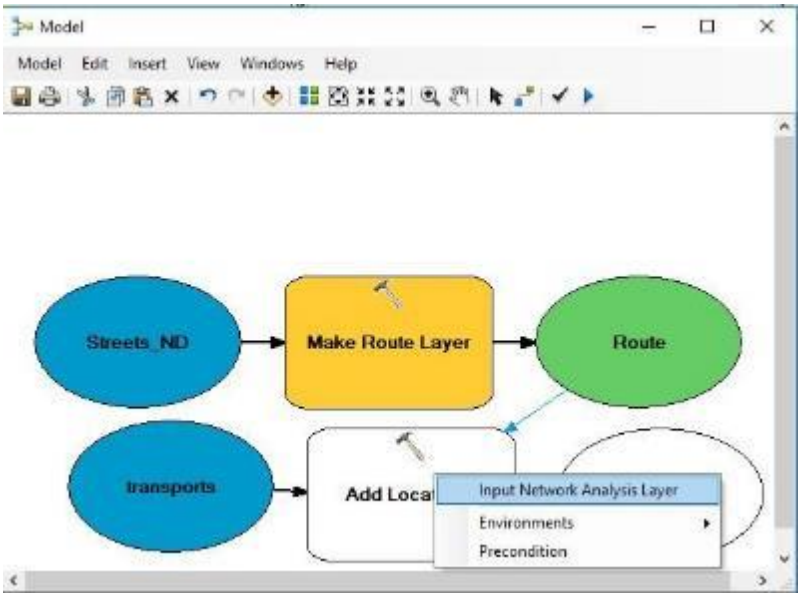


Figure 3.12

6. Click the Auto Layout button .The model is organized in a logical order.

7. Click on button (Full View) (Fig. 3.13).

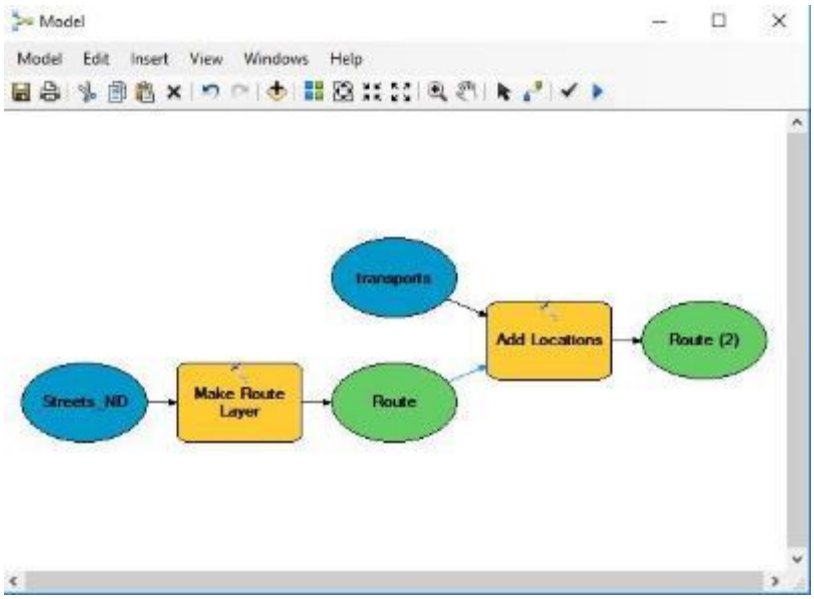


Figure 3.13

Adding a Calculation Tool (Solve) Steps:

1. Drag the Solve tool from the Search window to the Model dialog box (Figure 3.14).

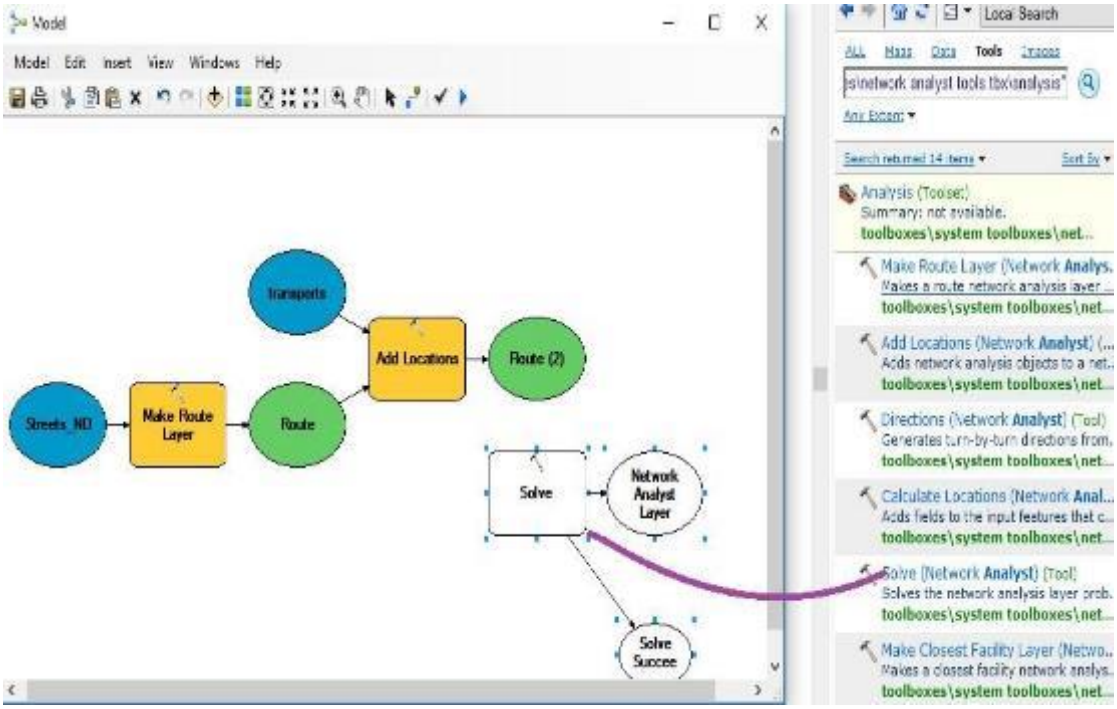


Figure 3.14

2. Using the Connect tool, lift the Route output layer (2) to the Calculation tool (Solve). In the context menu, click on the Input network analysis layer.

The Solve tool will turn yellow, the source layer will turn green, and the Solve succeeded will turn blue.

3. Click the Auto Layout button.

4. Click on button Full Appear (Full View) (Fig. 3.15).

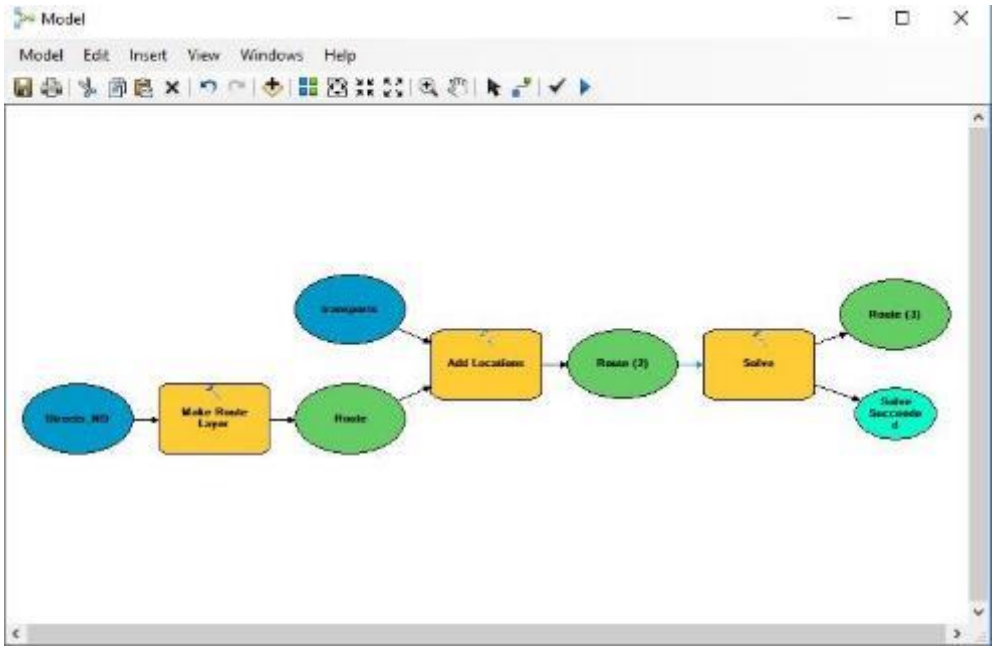


Figure 3.15

5. Click on the Select tool.

6. Right-click on the source layer of the tool

Add a provision, which is known as Route (2), and select the Add To Display command (Fig. 3.16).

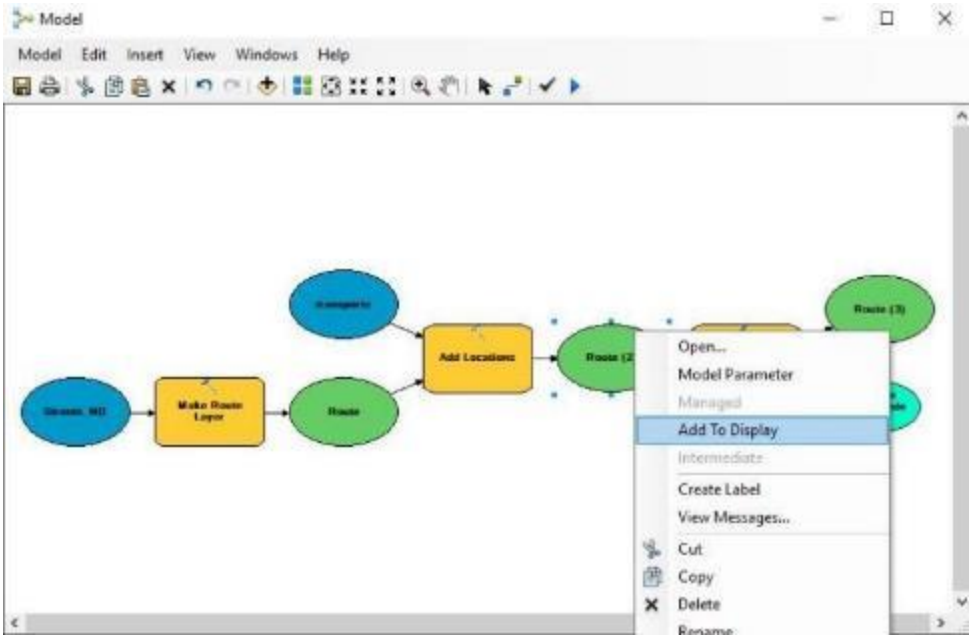


Figure 3.16

According to the Calculation (Solve), which is marked as Route (3), select the command Add To Display (Fig. 3.17).

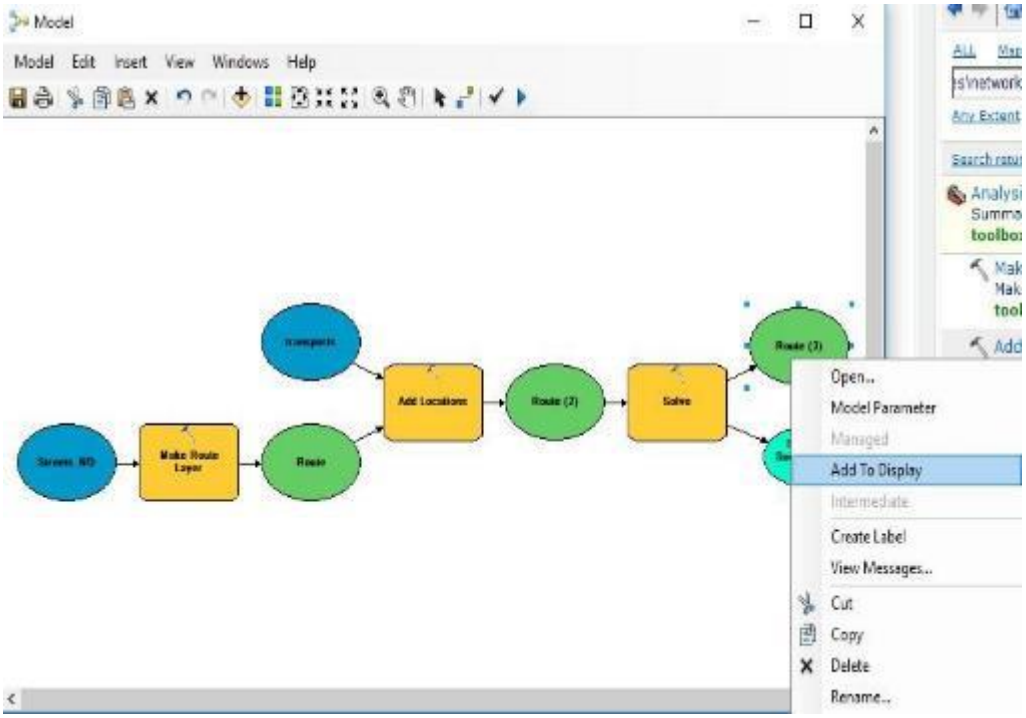


Figure 3.17

⚠ WARNING

The Add To Display command will not ensure that the result is added to the map when you run the tool from the toolkit. If you want to add the result to the map, right-click on the result (Layer Route (3)) and select Model Parameter (Fig. 3.18).

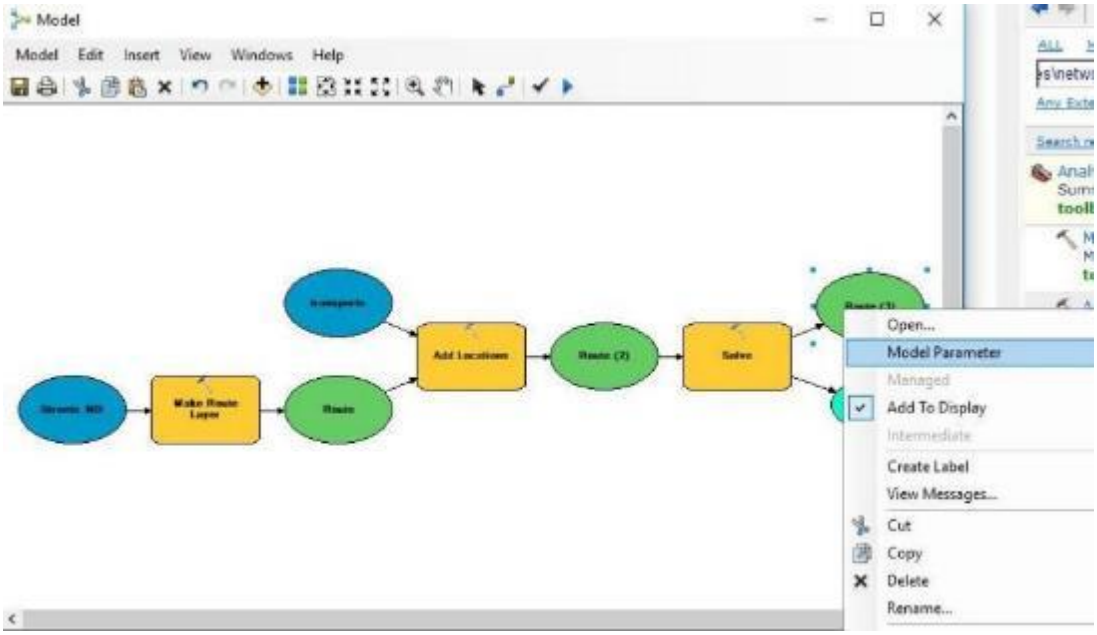


Figure 3.18

This will force the model to add the final result to the map display at startup from the Model dialog box.

Launch the model to find the best route

Steps:

1. Click the Save button, to save the model.
2. Click the Run button .

A status window appears showing ArcGIS route analysis.

3. Close the status window and the Model dialog box to view the results.

A tooltip appears indicating the need to save the model.

4. Click Yes.

The Network Analyst window displays all stops and the resulting route, so the map shows the downloaded stops and the resulting route (Fig. 3.19).

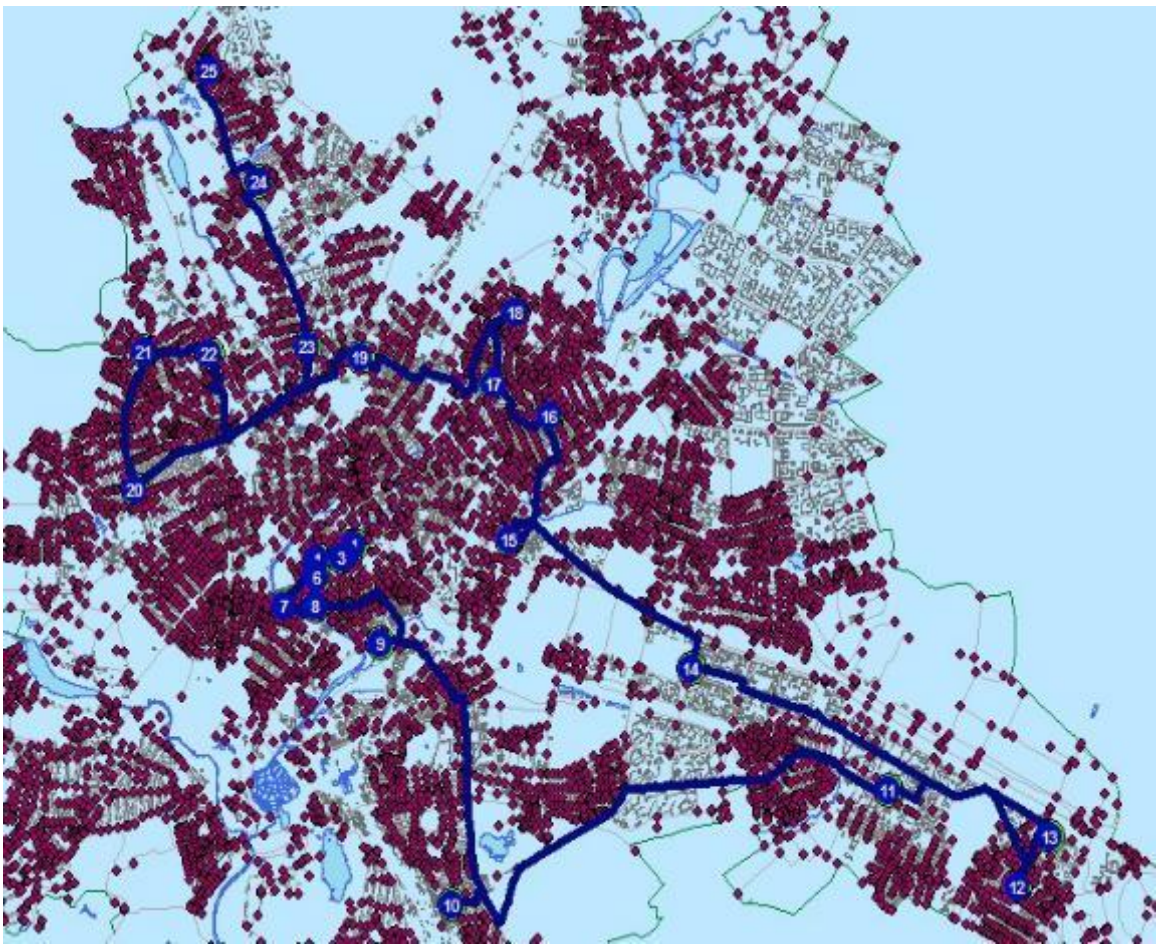


Figure 3.19

A new route layer has been added to the Table Of Contents window.

Adjust the model to save the results to disk

Steps:

1. In the Catalog window, expand the Network Model toolkit, right-click the Model node, and then click Edit.

For receiving access to functional class To determine the shortest route, you must first copy the characteristics from memory to disk.

2. Right-click on the model and select tools only for the model, and then - Select Data (Select Data) (Fig. 3.20).

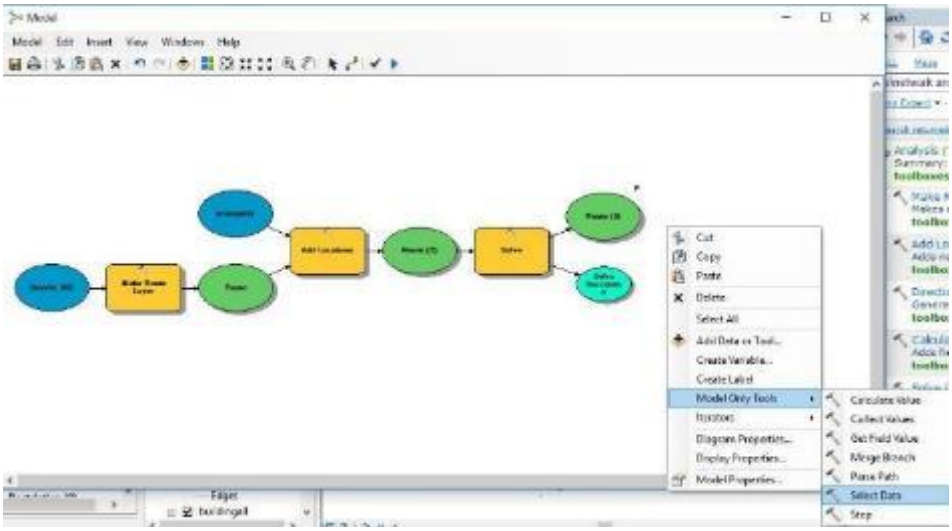


Figure 3.20

3. Using the Connect tool, drag the resulting output layer (Route 3) to the Select Data tool. Click on the Input Data Element in the context menu (Fig. 3.21).

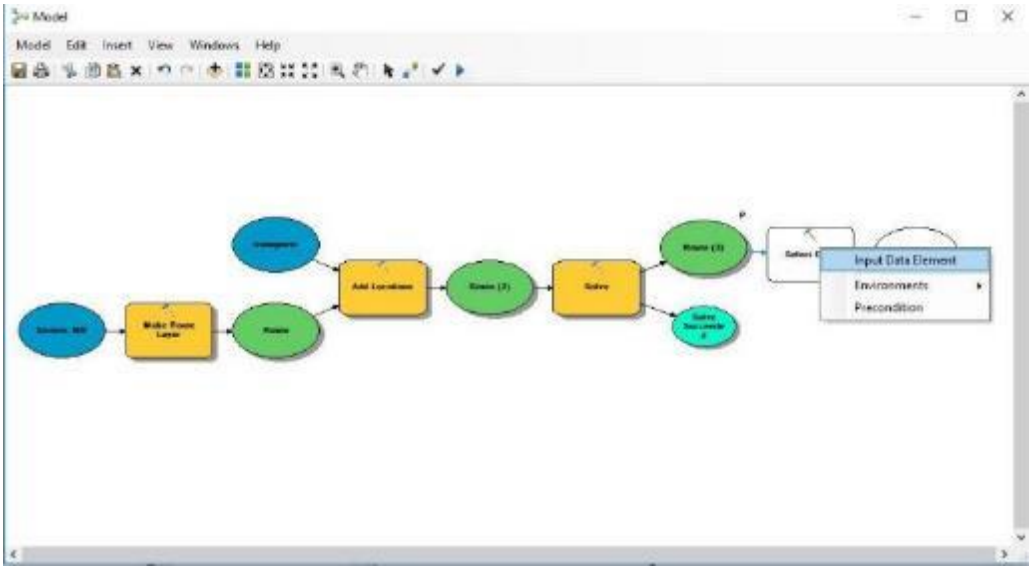


Figure 3.21

4. In the Model window, double-click the Select Data button. The Select Data dialog box opens (Figure 3.22).

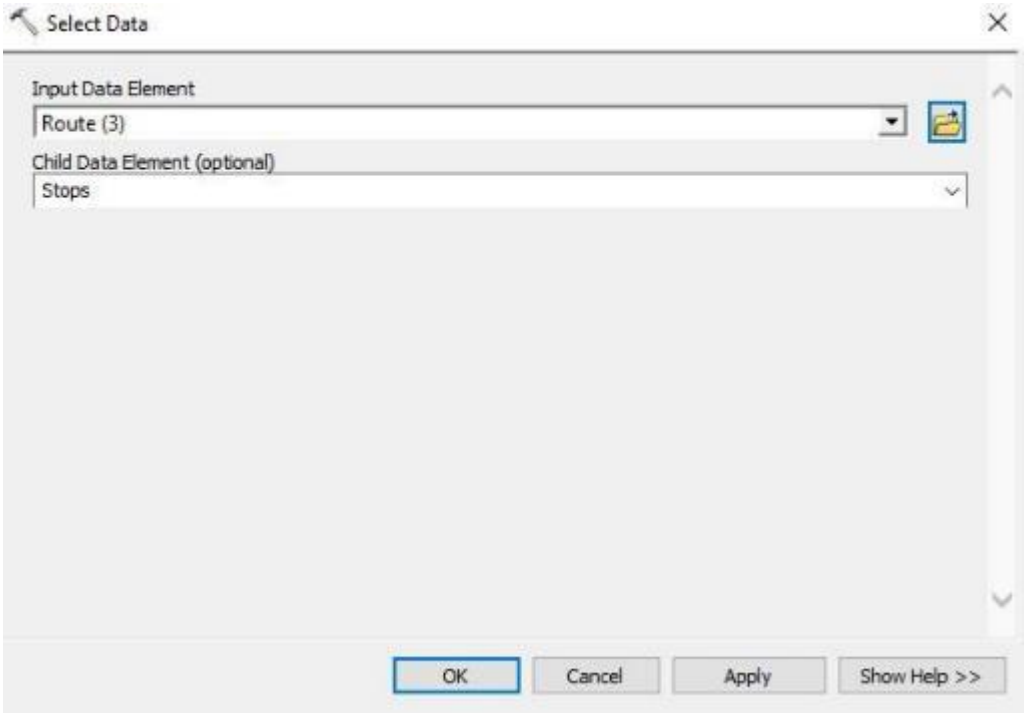


Figure 3.22

5. Select Routes in the Child Data Item list (Child Data Element) (Fig. 3.23).

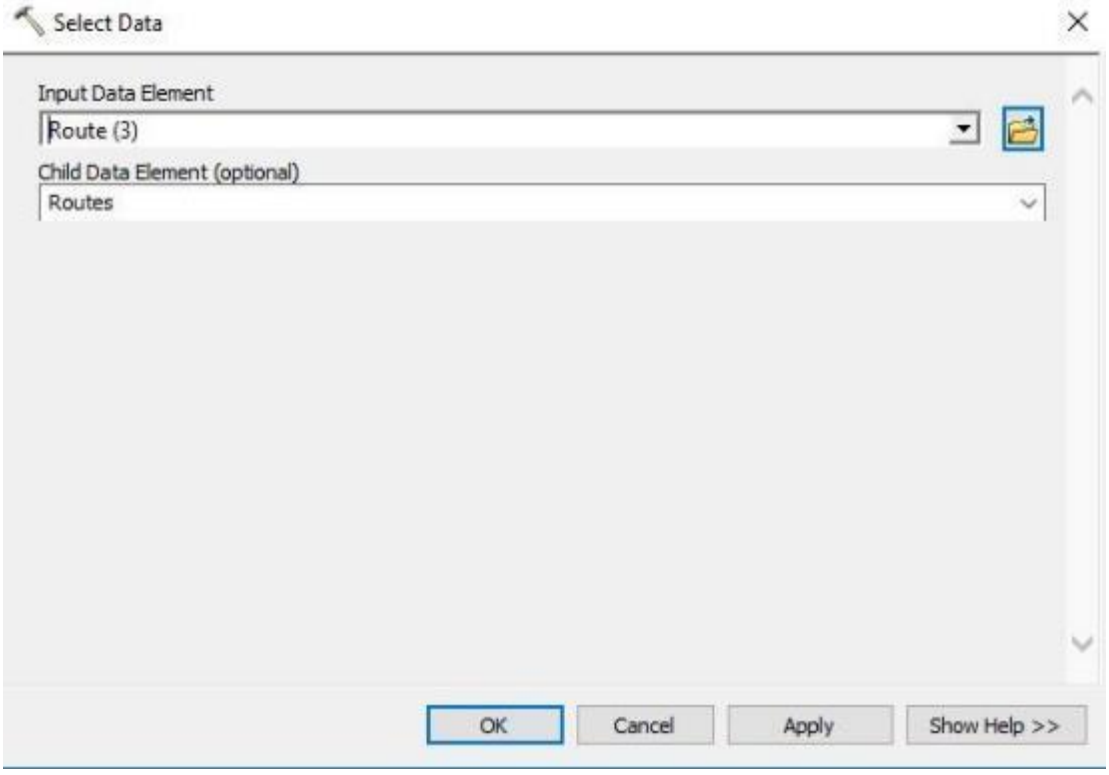


Figure 3.23

6. Click OK. The dialog box closes.

7. Type Copy Features in the text box of the Search window, and then press ENTER.

8. Drag tool Copying characteristics (Copy Features) from the search results in the Model dialog box (Fig. 3.24).

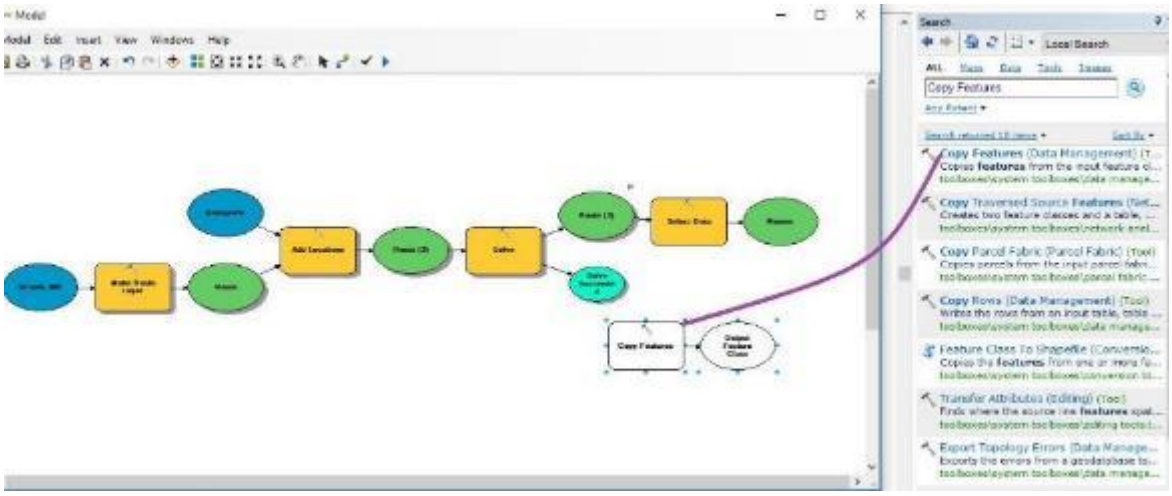


Figure 3.24

9. Using the Connect tool, drag the resulting source layer (Routes) to the Copy Features tool. Click on Input Features in the context menu (Fig. 3.25).

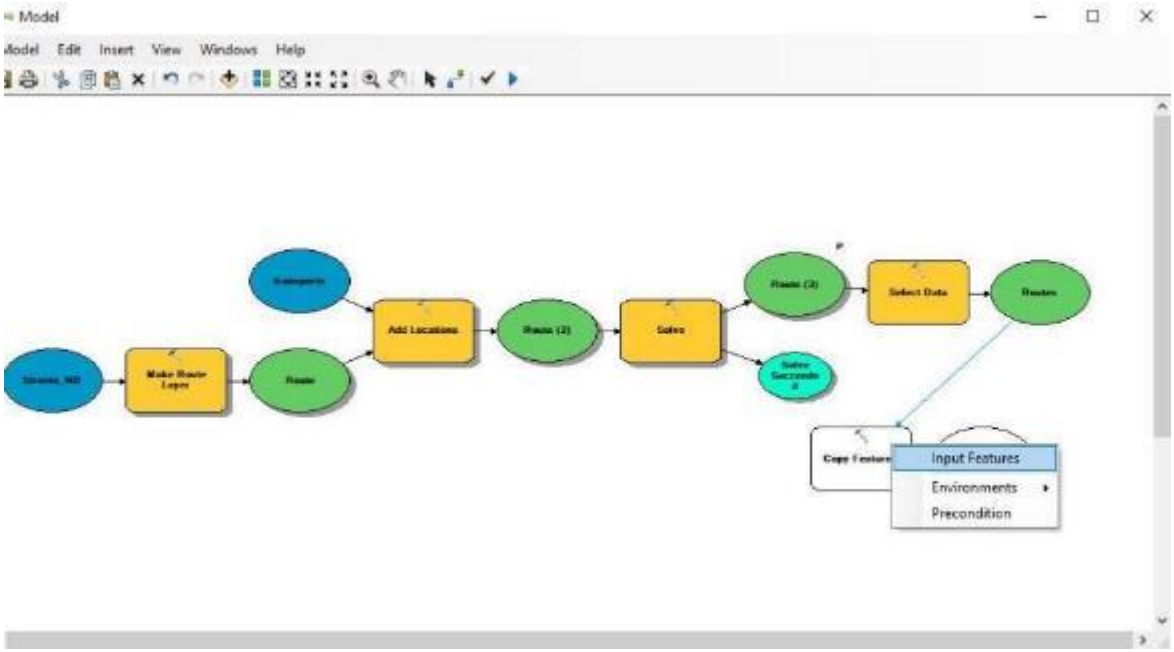


Figure 3.25

10. In the Model dialog box, double-click Copy Features.

It will open dialogwindow Copying characteristics (Copy Features) (Fig. 3.26).

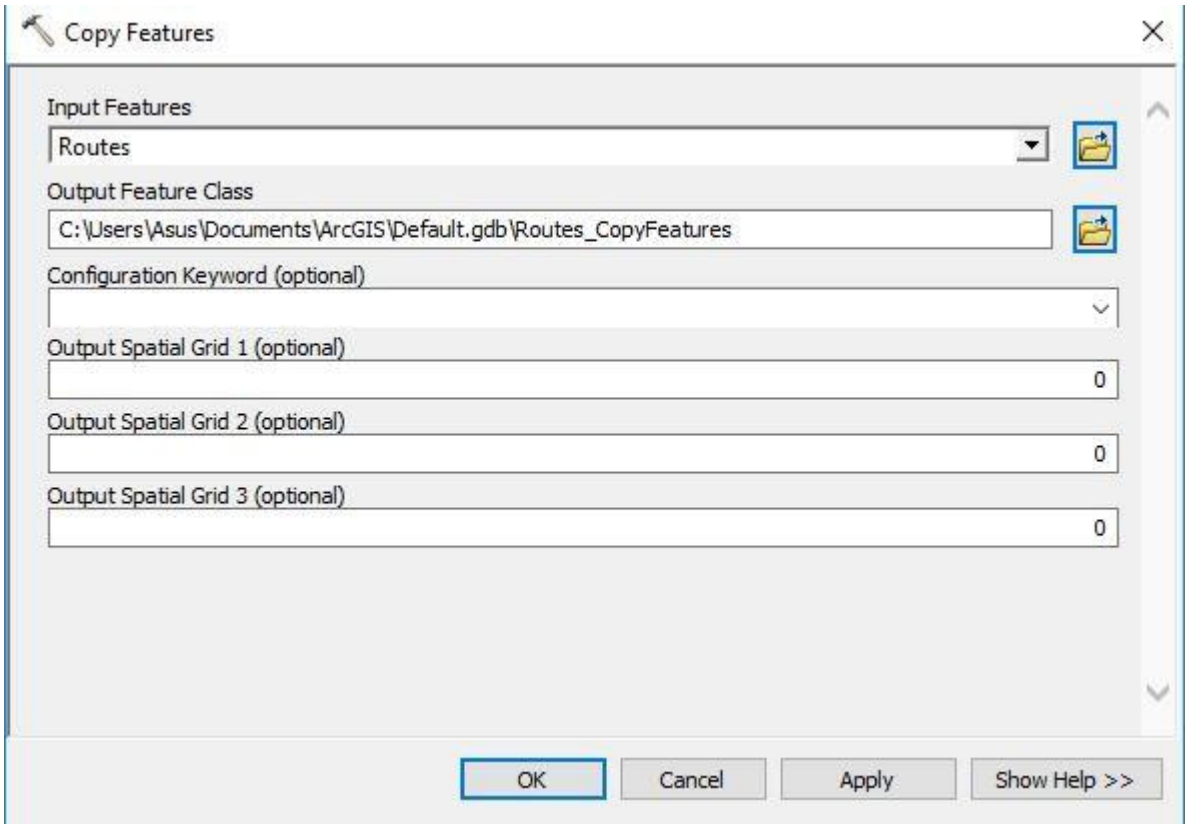


Figure 3.26

11. Enter the original location to save the route as a feature class or shapefile.

For example, you can enter the location C: \ arcgis \ ArcTutor \ Network Analyst \ Tutorial \ Exercise06 \ Kharkiv.gdb \ path.

12. Click OK.

Therefore, during the launch of the model, the most optimal route will be found and the sublayer of the route exported to the performance class will be selected. You can start the model by clicking the Run button .

Remove model

Steps:

1. In the Catalog window, go to the Network Model toolkit, right-click on the Model node, and select Delete (Figure 3.27).

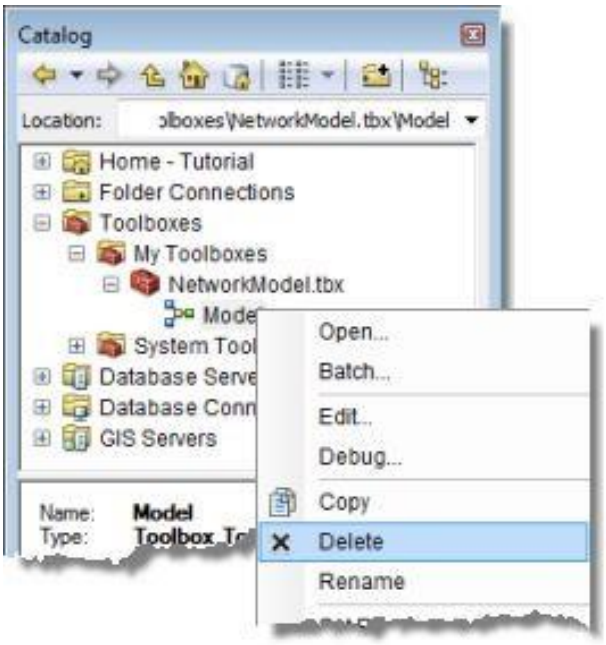


Figure 3.27

A tooltip appears indicating the need to confirm the deletion.

If the model was running, you also need to go to the folder specified to save the original data of the tool "Copy characteristics" and delete the created characteristic class.

2. Click Yes.

3. Exit ArcMap and do not save the changes to the Exercise6.mxd file.

3.2 Modeling of routes for freight transportation with definition basic parameters of their functioning

Municipal public freight transport is a vital subsystem of the municipal economy, the activity of which determines the functioning of all spheres of activity of cities, enterprises and organizations [64–73].

Management involves the impact on the object, selected from many possible influences, on the basis of available information that supports the stability or development of the object.

The managed object and the associated governing body form a management system. The control signals provided by the executive body on the basis of the processed information change the control actions in accordance with the control signals.

In the most general form of management can be defined as streamlining the system, ie bringing it in line with a certain objective pattern that operates in this environment. This wording contains one essential feature of management processes - their universality in the sense that they can be applied to any object, because there are no areas that could not be ordered. In form, this process is a combination of control and managed systems [39, 75].

Arranging and combining elements of the managed system provides a solution to the four main tasks of management - stabilization, program execution, monitoring and optimization.

Transport systems provide solutions to all four management tasks, but the effectiveness of the solution depends on the level of development of the transport system. In addition, the solution of the last two tasks requires a fairly high level of development and organization (orderliness) of the transport system.

Consider the content of management tasks in more detail.

The tasks of stabilizing the system [39, 75–76] are the task of maintaining some of its initial controlled values, close to some constant setpoints, without taking into account the influence of perturbations acting on the controlled values. Controlled values in transport systems are, for example, the downtime of cars at stations, the volume of loading and unloading, transportation, and so on. Dispatchers constantly monitor the actual values of these indicators, ie compare them with the normative values, and in case of deviation from the normative ones make appropriate decisions.

The task of the program occurs when the set values of the controlled values change over time in a predetermined way. For example, the dispatcher of the

automobile station on industrial transport in the performance of his duties is guided by the requests of the shops for the supply and cleaning of cars - the program of transport maintenance of production; the dispatcher of the sorting station monitors the observance of the plan of cargo formation - the document (program), which regulates the composition of each formed car, as well as the observance of the schedule of shipments.

In cases where the scheme of changing the set values of the controlled values is not known in advance, the problem of tracking is solved, ie the most accurate compliance with the current state of the system to the variable controlled values. Controlled values [77] must be changed to bring the state of the system in line with the changed external and internal conditions. In this sense, the system that implements tracking is similar to the system that solves the problem of stabilization, but in the tracking system, the controlled values are not constant. The need for monitoring arises, for example, when driving in conditions of significant unevenness of cargo flows or frequent changes in the parameters of applications for the supply and cleaning of cars. In this case, the dispatcher must promptly adjust the formation plan, schedule, volume of shunting work, to ensure compliance with the basic regulatory performance of the station - the values of downtime and turnover of cars, the volume of loading and unloading, indicators of quality of customer service. In some cases, the control task can not be formulated as the task of ensuring compliance with the state of the system to a given (constant or variable), because information about the given state can neither be pre-entered into the control system or obtained during its operation. This situation arises, for example, during the management of a station operating in difficult changing conditions, if the purpose of management is to ensure optimal (maximum) compliance with the values of the station's performance in any mode of its operation. indicators of quality of transport service of clients. In some cases, the control task can not be formulated as the task of ensuring compliance with the state of the system to a given (constant or variable), because information about the given state can neither be pre-entered into the control system or obtained during its operation. This situation arises, for example, during the management of a station operating in difficult changing

conditions, if the purpose of management is to ensure optimal (maximum) compliance with the values of the station's performance in any mode of its operation. indicators of quality of transport service of clients. In some cases, the control task can not be formulated as the task of ensuring compliance with the state of the system to a given (constant or variable), because information about the given state can neither be pre-entered into the control system or obtained during its operation. This situation arises, for example, during the management of a station operating in difficult changing conditions, if the purpose of management is to ensure optimal (maximum) compliance with the values of the station's performance in any mode of its operation. since information about the specified state can be neither pre-entered into the control system, nor obtained in the course of its operation. This situation arises, for example, during the management of a station operating in difficult changing conditions, if the purpose of management is to ensure optimal (maximum) compliance with the values of the station's performance in any mode of its operation. since information about the specified state can be neither pre-entered into the control system, nor obtained in the course of its operation. This situation arises, for example, during the management of a station operating in difficult changing conditions, if the purpose of management is to ensure optimal (maximum) compliance with the values of the station's performance in any mode of its operation.

Management systems that solve the problem of monitoring and optimization, more adequately respond to changes in external and internal conditions, adapt, adapt to these changes and, unlike systems that solve only the tasks of stabilization and implementation of programs, able to maintain their structure and maintain viability significant perturbing effects. For example, the management systems of domestic enterprises, formed in the stable conditions of the planned economy, were focused mainly on solving the first two management tasks. Under market conditions, such management systems are inefficient and need to be improved. Businesses that do not change their management system in a timely manner cannot adequately respond to market demands. Road transport, as a monopolist in the market of mass transportation for short, medium and long distances,

Urban freight transport management systems solve the following tasks [40, 81]:

1) streamlining of cargo;

2) maintaining a single accounting of cargo flows;

3) optimization of the company's activities for the delivery of goods in large cities and regions, optimization of transportation and reduction of transport costs;

4) planning, accounting and CONTROL processes related from

shipment and delivery of goods and cargoes;

5) reduction of cargo delivery costs;

6) improving the quality of customer service;

7) software reliability work all transport and road infrastructure and reduction impact automotive transport on the environment .;

8) increasing the accessibility of transport services for all groups of the population.

To automate the control process, automatic control systems are used.

This section is dedicated to finding the best routes for the fleet of a distribution company that delivers goods from the distribution center to 25 retail centers. Each center has certain needs for goods, and each truck is characterized by a certain limitation of the capacity of the goods.

The goal is to select fleet trucks according to a set of retail centers and distribute deliveries so as to reduce overall transportation costs.

Therefore, you need to define a transport route (VRP). Once you have established the delivery sequence, you can develop step-by-step instructions for the resulting routes, which can be sent electronically or printed out and passed on to drivers working on delivery routes.

Data for this and other Network Analyst tasks are available at ArcGIS.com. Once you've downloaded the data, you can drag it anywhere, but it's more convenient in the C: \ arcgis \ ArcTutor folder, as this folder is listed in the exercises as the default location for the training data.

Preparing the display

Steps:

1. Activate the ArcGIS Network Analyst plug-in by following these steps:

a) click on Customize> Additional modules (Extensions). The Extensions dialog box opens;

b) mark ArcGIS Network Analyst;

c) click Close.

If the Network Analyst toolbar doesn't appear, you'll need to add it.

2. Click Customize> Toolbars> Network Analyst.

The Network Analyst toolbar will be added to ArcMap (Figure 3.28).

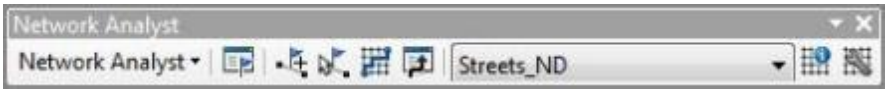


Figure 3.28

If the Network Analyst window does not appear, you need to add it.

3. On the Network Analyst toolbar, click the Network Analyst window.

The attached Network Analyst window will open (Fig. 3.29).

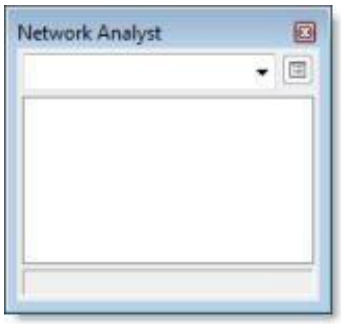


Figure 3.29

The Network Analyst window can be pinned and unpinned.

Create an analysis layer to select the transport route

Steps:

1. Click Network Analyst on the Network toolbar Analyst and on the New Vehicle Routing Problem (Fig. 3.30).

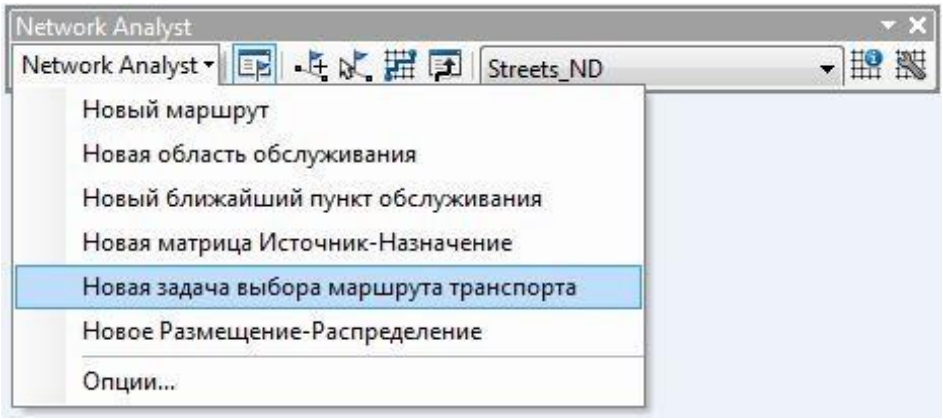


Figure 3.30

The analysis layer of the transport route selection task has been added to the window

Network Analysis Classes: Orders, Depots, Routes, Depot Visits, Breaks, Route Zones, Route Seed Points, Route Updates (Route Renewals), Special Requirements, Order Pairs, Point Barriers, Line Barriers and Polygon Barriers - Empty).

Figure 3.31

A new layer of analysis has also been added to the Table Of Contents window (Fig. 3.32).

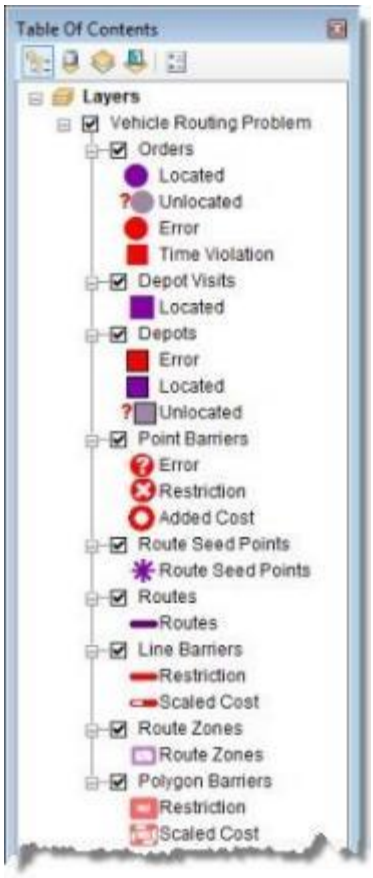


Figure 3.32

Adding orders

The location of the retail centers will be added to the Orders network analysis class. Orders can be submitted as orders that need to be fulfilled, as each retail center orders a certain amount of goods from the distribution center. Orders will eventually mark stops on the transport route.

The location of retail centers has already been added as a Centers feature layer to the map document. The Centers layer attributes contain information about the total weight of the goods (in pounds) required by each center, the time when delivery should be performed and the time of unloading (in minutes) at each center. Unloading time is the time required to unload the goods.

These point characteristics of retail centers will be added to the analysis layer as an order.

Steps:

1. In the Network Analyst window, right-click the button Orders (Orders (0)) and choose Load Location (Load Locations) (Fig. 3.33).

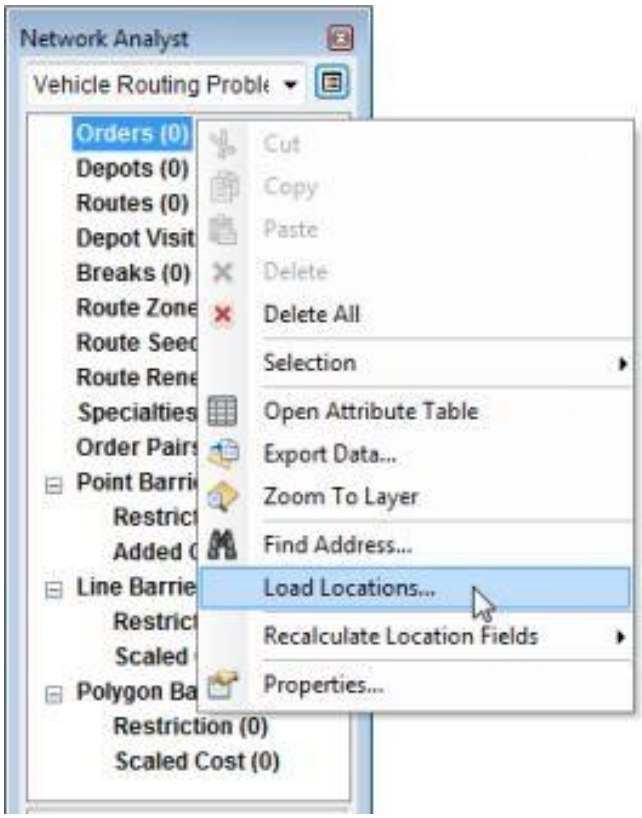


Figure 3.33

The Load Locations dialog box opens.

2. Select Centers from the Load Locations list.

The Location Analysis Properties section of the Load locations dialog box allows you to specify which attributes of the Retail Centers feature class contain values that will be used by the ArcGIS Network Analyst Plugin when solving a transport route selection task.

3. In the Location Analysis Properties section, make sure that the Name property automatically displays the NAME field and the Service Time property automatically displays the Service Time field.

The ArcGIS Network Analyst plug-in attempts to automatically link location analysis properties for a new transport route selection task layer using a configuration file located in the ArcGIS installation folder in [... [\ NetworkAnalyst \ NetworkConfiguration \ NASolverConfiguration.xml).

4. Set the value of the Field of the Time Window Start 1 property for the Time Start 1 property (Fig. 3.34).

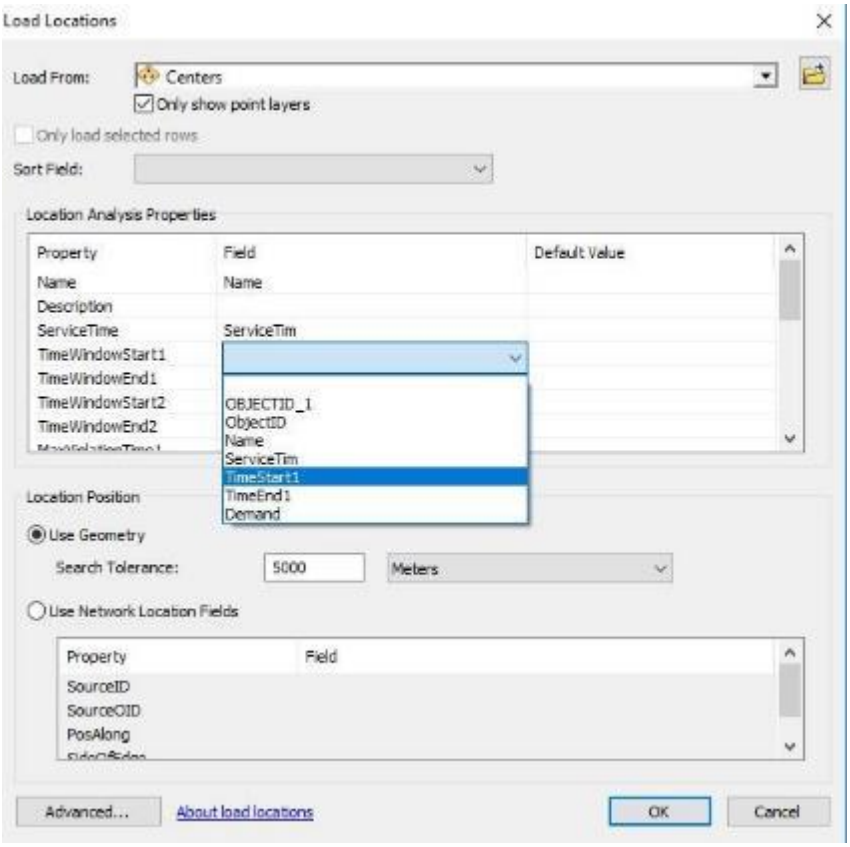


Figure 3.34

5. Set the Field value of the Time Window End 1 property for the Time End 1 attribute.

6. Set the Field value of the Delivery Quantities property for the Demand attribute.

7. Enter a value of 0 on the Default Value tab for the Max Violation Time 1 attribute.

If you set the value of zero to this property, it will mean that the delivery time can not be violated (Fig. 3.35).

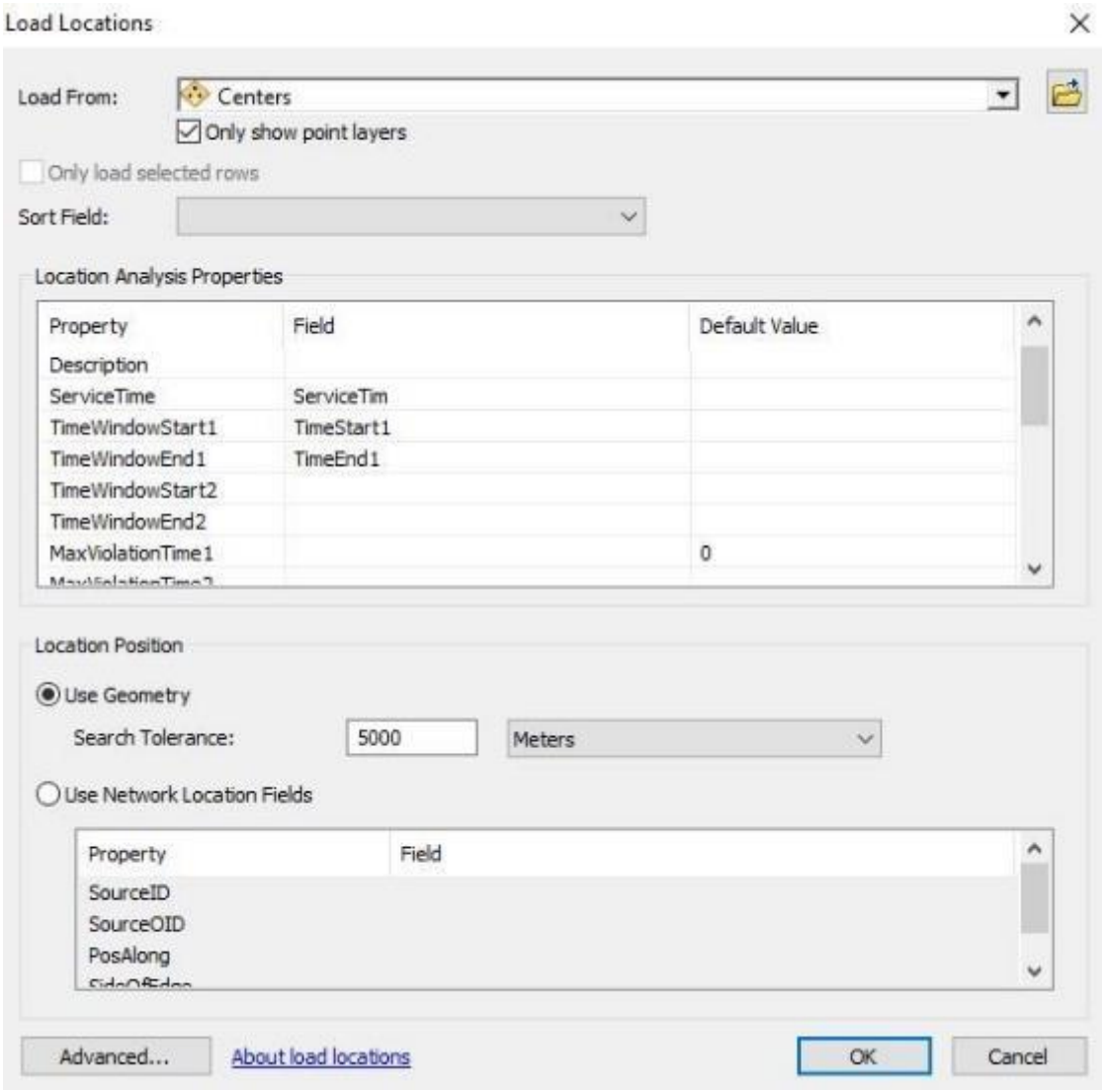


Figure 3.35

8. Click OK.

The 25 retail centers are listed in the Network Analyst window on the Orders tab as an order on the map.

9. Double-click Store_1.

The properties of the store are opened (Fig. 3.36).

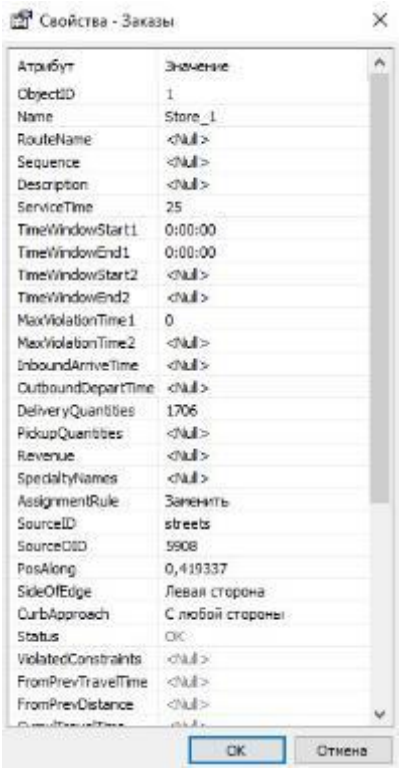


Figure 3.36

10. Set the required properties: Time Window Start 1 at 9 am (9:00:00), Time Window End 1 at 5 pm (17:00:00) (Fig. 3.37).

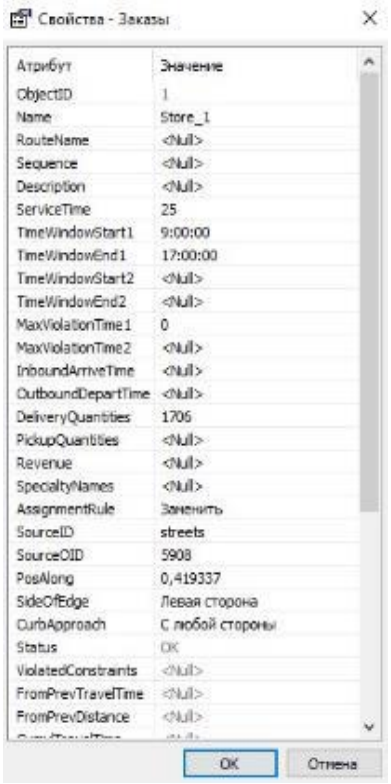


Figure 3.37

11. Repeat steps 9 through 10 for the next 24 centers.

Adding syllables

Goods are delivered from a single distribution center, the location of which is marked on the Distribution Center spatial object layer in ArcMap. The distribution center is open from 8 am to 5 pm. This point characteristic must be added to the Depots network analysis class.

Steps:

1. In the Network Analyst window, right-click the button Warehouses (Depots (0)) and select Load Locations.

The Load Locations dialog box opens Locations.

2. Choose Center distribution (Distribution Center) with list Load Locations.

3. In the Location Analysis Properties section make sure what property Name automatically matches the NAME field.

4. Enter a value of 8 AM in the Default Value field for the Time Window Start property 1.

5. Enter a value of 5 PM in the Default Value field for the Time Window End 1 property (Figure 3.38).

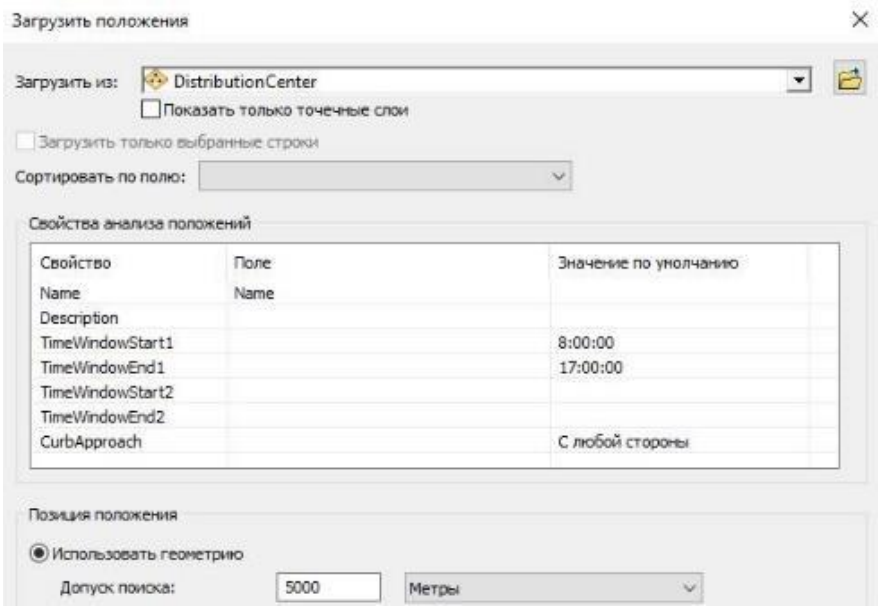


Figure 3.38

6. Click OK.

One distribution center is listed in the Network Analyst window on the Depots tab and is displayed as a warehouse on the map.

Add routes

At the center of the distribution are three trucks, each of which can carry no more than 15 thousand pounds of goods. You need to add three routes (one for each truck) and set the properties for the routes according to the instructions of the distribution center.

Steps:

1. In the Network Analyst window, right-click the Routes (0) button and select Add Item (Fig. 3.39).

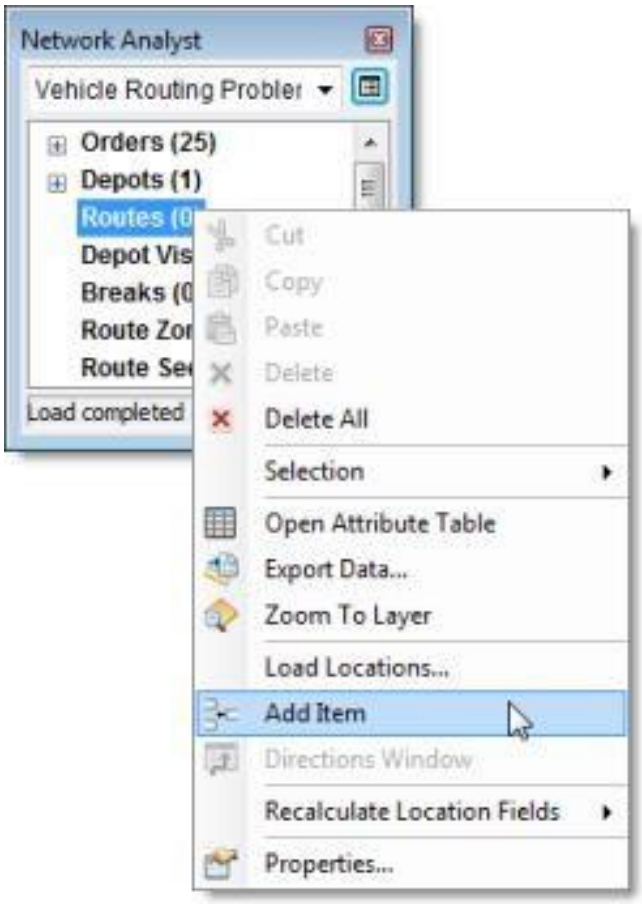


Figure 3.39

The new route Element 1 will be added to the class tab Routes in the Network Analyst window, then the Properties window for the route will open.

2. In the Properties window (Fig. 3.40) specify the attributes for the route, as shown in the table below. The description column provides explanations for each value. Do not change the default attribute values in the table.

Hint

Use the following keyboard shortcuts to change the values in the Properties window:

- Click the TAB or F2 key to change the outfit property.
- Click the TAB key again to save the changes and proceed to change the next property.
- Click SHIFT + TAB to save the changes and go to the previous property.

Table 3.1 - Branches

Name	Value	Description
1	2	3
Name	Truck_1	Vehicle name
(Start Depot Name)	Kharkiv	The truck starts moving along the route from the distribution center
(End Depot Name)	Kharkiv	The truck returns to the distribution center at the end of the route
(Start Depot Service Time)	60	The time (in this case in minutes) required to fully load the truck with goods
(Earliest Start Time)	8 AM	The truck can start delivery immediately after the opening of the distribution center at 8 o'clock
(Latest Start Time)	8 AM	The truck must start work as soon as possible

Continuation of table 3.1

Capacity ()	15,000	The truck can carry no more than 15 thousand pounds of goods
(Cost Per Unit Time)	0.20	The driver of the truck receives $ 12 per hour, his salary can be calculated as $ 12/60 min = 0.20 cents per minute
(Cost Per Unit Distance)	1.5	Average cost in dollars per mile, including fuel consumption, truck depreciation and maintenance
(Max Order Count)	10	The maximum number of stores that can be serviced by a truck
(Max Total Time)	360	Due to the restriction of the working day, drivers cannot work for more than 6 hours (360 minutes)
(Max Total Travel Time)	120	In order not to violate the restrictions of the working day and to serve a sufficient number of retail centers, given the time of unloading at each store, the truck should spend no more than 2 hours (120 minutes) on the streets
(Max Total Distance)	80	To balance daily fuel and maintenance costs for the entire fleet, each truck must travel no more than 80 miles

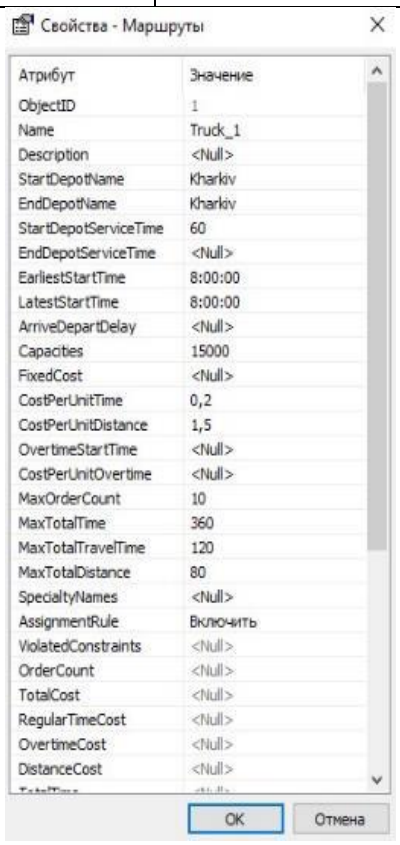


Figure 3.40

3. Click OK.

The new Truck_1 route will be added to the route class in the Network Analyst window.

Since the three trucks in the center of the distribution do not differ from each other, you can make two copies of the first truck and rename them.

4. Right-click on the Truck_1 route object in the Network Analyst window and select Copy (Fig. 3.41).

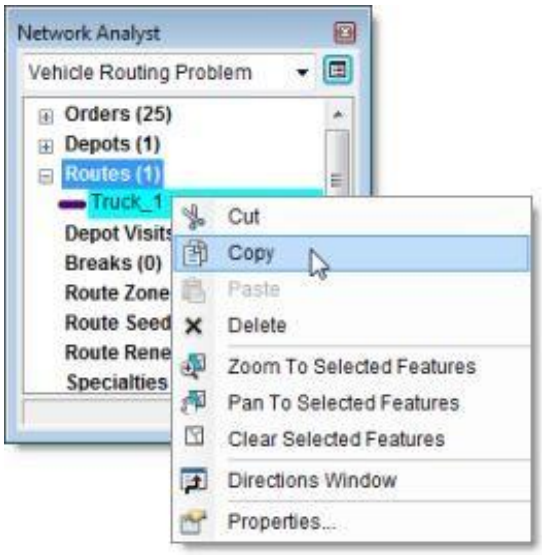


Figure 3.41

5. Right-click on the Route class (1) in the Network Analyst window and select Paste (Fig. 3.42).

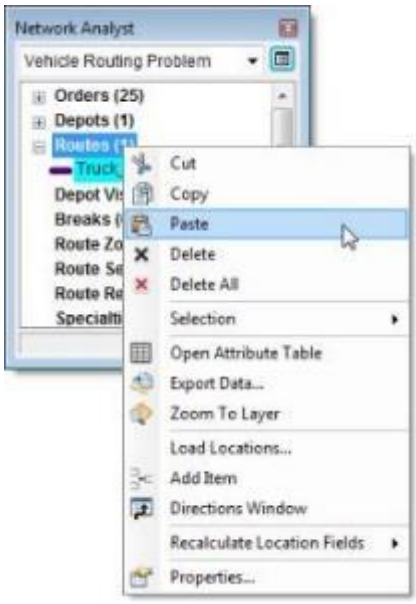


Figure 3.42

The Routes class contains two identical route objects.

6. Repeat the previous step to create a third route object (Fig. 3.43).

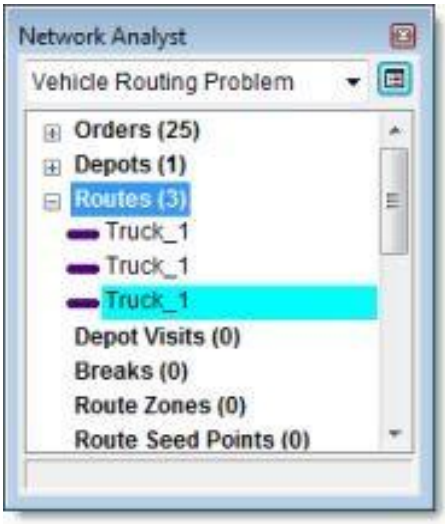


Figure 3.43

7. Double-click on the second Truck 1 object from the list.

The Properties window opens.

8. Click on the Name property and enter Truck_2.

9. Double-click the ENTER key.

The route will be given a unique name and the window will close.

10. Use the same procedure to change the name of the last route to Truck_3 (Fig. 3.44).

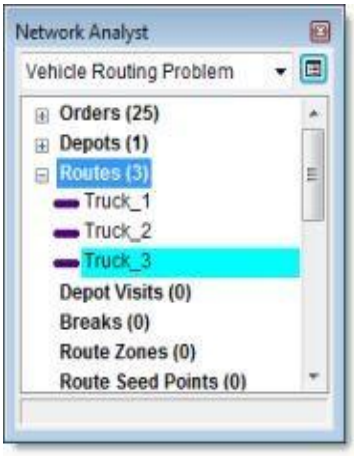


Figure 3.44

Setting properties for the analysis of the task of determining the transport route

Steps:

1. Click the Analysis Layer Properties button in the Network Analyst window (Fig. 3.45).

Figure 3.45

2. The Layer Properties dialog box opens.

3. Click the Analysis Settings tab.

Make sure that the Time Attribute list that opens is set to Travel Time in Minutes.

The VRP task solver uses this attribute to calculate costs between customers and warehouse on a time-based basis.

4. From the Distance Attribute list, select Meters.

This attribute is used to calculate the distances between customers and the warehouse in order to limit the creation of routes, although the purpose of the VRP task tool is to minimize costs in terms of time.

5. Set the Default Date property to Day of Week. Choose Monday from the Day of Week list.

6. Make sure the Capacity Count is set to 1.

This value indicates that the goods being delivered are measured by only one indicator. In this case, this figure is weight (in pounds). If the capacity was indicated by two indicators, such as weight and volume, the capacity meter would have a value of 2.

7. Make sure what value Minutes given the Time Field Units properties.

This property indicates that all attributes are timed, such as Service

Time and Max Violation Time 1 for the Orders class and Max Total Time, Max Total Travel Time and Cost Per Unit Time for the Route class, are set in minutes.

8. Make sure that the Distance Field Units property is set to Kilometers.

This property indicates that all distance attributes, such as Max Total Distance and Cost Per Unit Distance, are specified in miles for the Routes class.

9. Because these trucks cannot perform U-Turns at Junctions, the U-Turns at Junctions properties must be set to Not Allowed.

10. Select Straight Line from the Output Shape Type list.

If necessary, you can select True Shape with Measures or True Shape to route through the streets. Keep in mind that this setting only affects the display of routes, not the results determined by the VRP tool.

11. Make sure Restricted Turns and One way are highlighted in the Restrictions section.

12. Leave the parameters in the Directions set unchanged (Fig. 3.46).

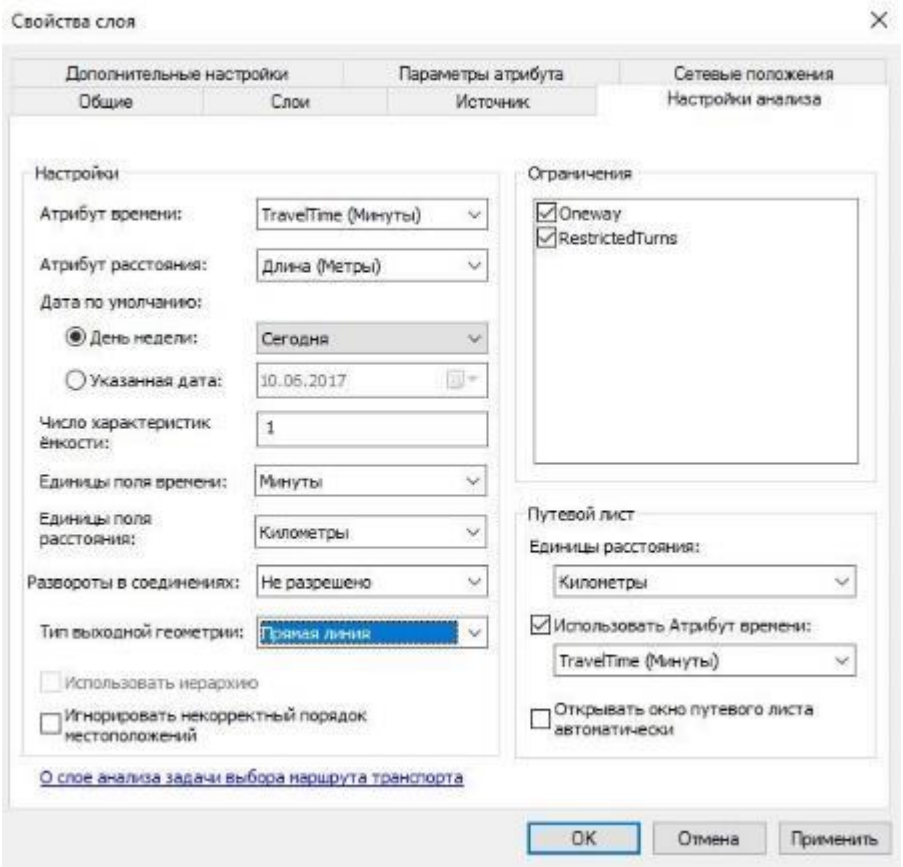


Figure 3.46

13. Click OK.

The process of determining the best route and sequence of orders

Steps:

1. Click the Solve button Network Analyst toolbar.

2. When receiving error messages, make sure that the Capacities attribute for routes is 15,000 instead of 15,000, and that each route is given a unique name (Figure 3.47).

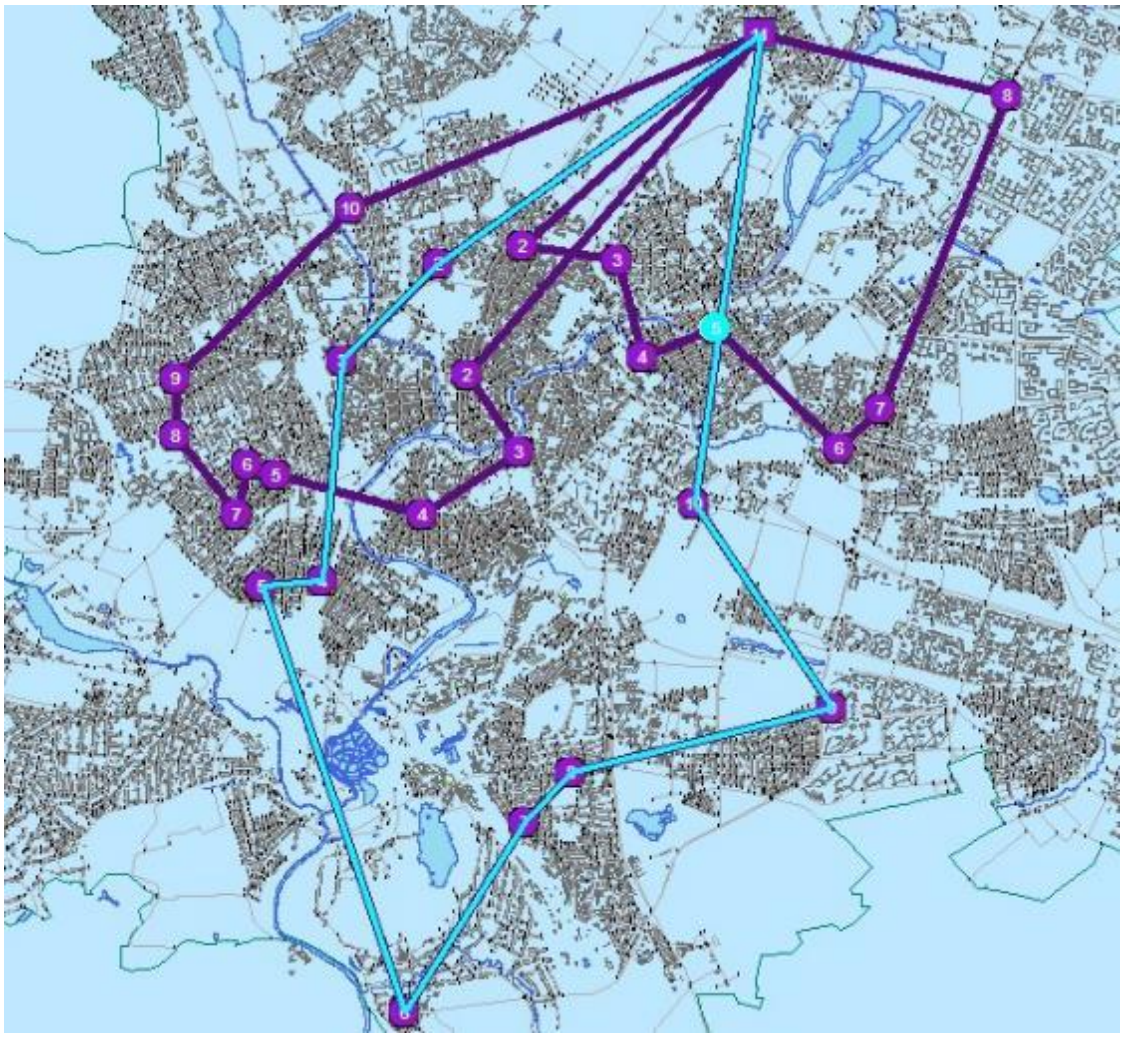


Figure 3.47

The VRP task calculator calculates the three routes required to service orders and draws the lines connecting the orders. Each route starts and ends at the distribution center and serves a set of orders on the corresponding route.

Defining step-by-step directions for routes

Steps:

1. Right-click the Routes (3) button in the Network Analyst window and select Selection> Clear Selected Features.

2. Click the Directions Window button Network Analyst toolbar.

The Directions dialog box opens.

3. In this case, you can export the transport route definition task layer as a layer file (<filename> .lyr) by right-clicking on the Vehicle Routing Problem button in the Table Of Contents window and selecting Save As. Save As Layer File. This command will save the analysis to disk, after which it can be added to another map document and used later.

4. If you need to continue working and go to other sections of this exercise, you need to close the Directions window. Otherwise, exit ArcMap and do not save the changes to the Exercise 07.mxd file.

Make changes to the decision to run another scenario

The company decided on the transport route used earlier, but a few weeks later the driver of the Truck_2 route went on vacation. The distribution company must service the same number of retail centers using only two trucks. To accommodate the extra workload, the company decided to pay two other drivers overtime and give them one paid break during the day. The distribution company also acquired two additional distribution centers. These centers can be used by trucks to replenish loading and continue the delivery route instead of returning to the main distribution center for the next loading. You need to change the decision, take the previous step, and take these changes into account.

Delete the existing route from the solution

In the Network Analyst window, right-click the Truck_2 object in the Routes class and select Delete

(Fig. 3.48).

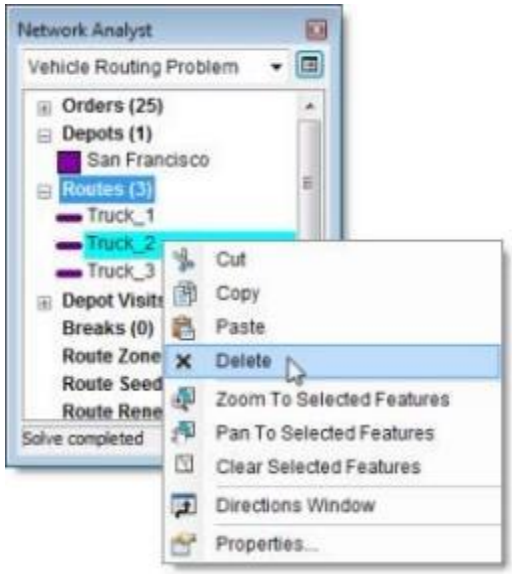


Figure 3.48

The selected Truck_2 object will be deleted.

Add downloads on the route

Two additional distribution centers, purchased by the company, are located on the street. Pushkinskaya, 25 and Plekhanovskaya, 66. They can be used for additional loading of trucks. Trucks can replenish loads in these distribution centers, and thus save time without returning to the original warehouse. New distribution centers need to be added to the Depots network analysis class, specifying the geocode of their address. Routes on which it is possible to replenish cargoes in additional distribution centers, and loading time in them are specified in a class of the analysis of a network Replenishment of loading on a route (Route Renewal).

Steps:

1. In the Network Analyst window, left-click on the button Warehouses (Depots (1)). Then click the Find button on the toolbar (Fig. 3.49).

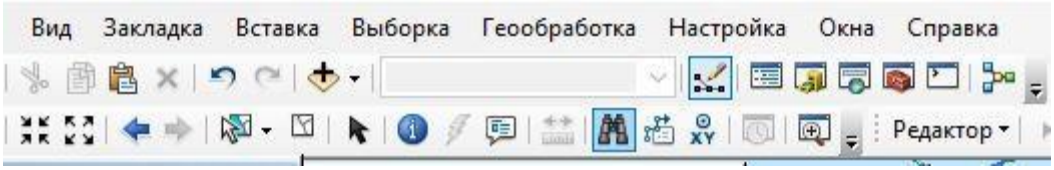


Figure 3.49

The Find dialog box opens.

2. Select the Spatial Objects tab.

3. Select the buildingall layer in the value of B (In) (Fig. 3.50).

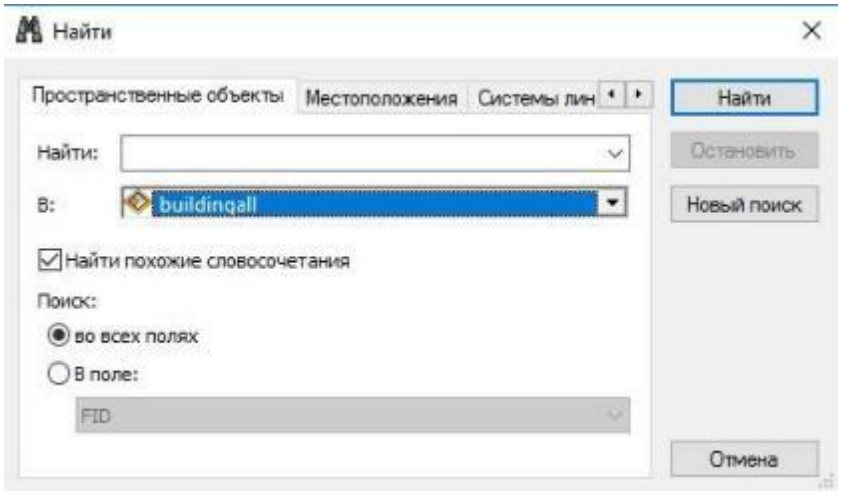


Figure 3.50

4. In the Find text box, enter a street name - Pushkinskaya, 25.

5. Click Find.

6. Right-click in the Find dialog box (Find) and select Add as Network Analysis Object.

The new address will be added as a warehouse to the Network Analyst window and display on the map (Fig. 3.51).

Figure 3.51

7. In the Find text box, enter a street name - 66 Plekhanivska Street.

8. Click Find.

9. Right-click the new result at the bottom of the Find dialog box and select Add as Network Analysis Object.

The third warehouse will be added as a network analysis class Warehouses (Depots) (Fig. 3.52).

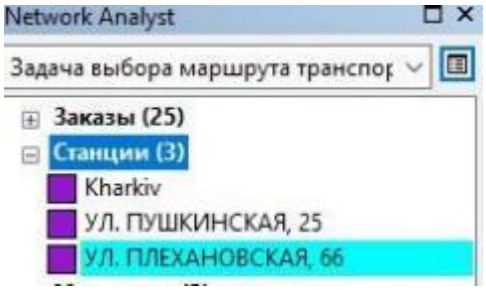


Figure 3.52

10. Close the Find dialog box.

As both trucks can update loads at Pushkinskaya, 25 and Plekhanovskaya, 66, it is necessary to "tie" each truck to two places of replenishment of loading. The program for solving the problem of choosing the route of transport will calculate the optimal

location of replenishment for trucks, as well as determine when they should replenish their stock of goods.

11. In the Network Analyst window, right-click on the Route Renewals (0) button and select Add Item (Figure 3.53).

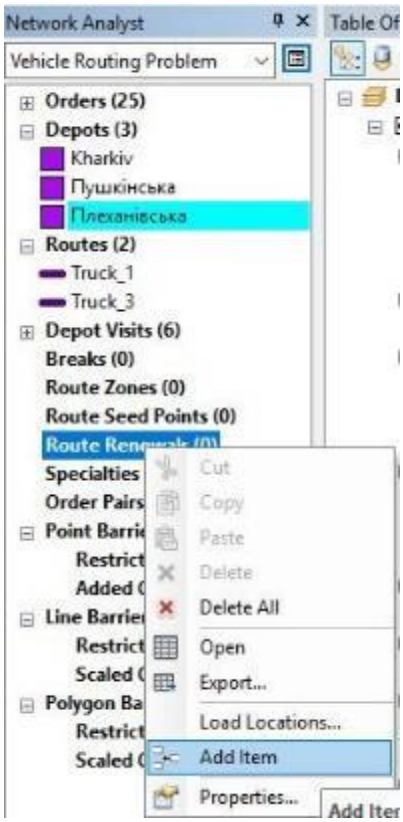


Figure 3.53

A new item replenishment object on Route Item1 will be added to the Oute Renewals class tab in the Network Analyst window, and then the Properties window for Item1 will open.

12. In the Properties window, specify the attributes to replenish the download on the route, as shown in Table 3.2 and Figure 3.54.

Table 3.2 - Attributes to replenish the download on the route

Attribute	Value	Description
1	2	3
(Depot Name)	Pushkin, 25	Truck can use this composition to replenish cargo
(Route Name)	Truck_1	Vehicle name
(Service Time)	30	Time in minutes required to load the truck goods

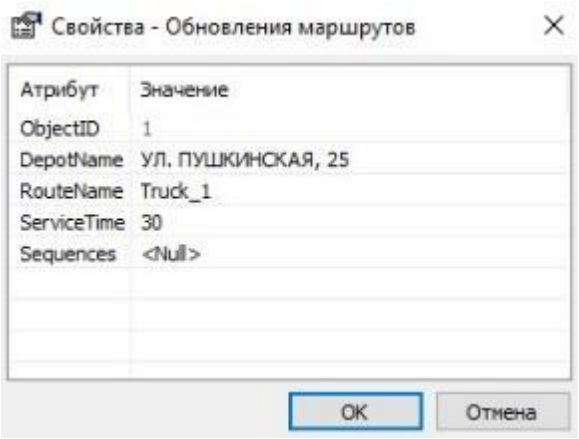


Figure 3.54

13. Click OK.

A new boot replenishment object on Pushkin Route 25 will appear inside the Truck_1 element in the Network Analyst window.

14. Follow the last three steps to add three more replenishment items on the route so that each truck (Truck_1 and Truck_3) can be replenished at both additional warehouses (Pushkinskaya, 25 and Plekhanovskaya, 66).

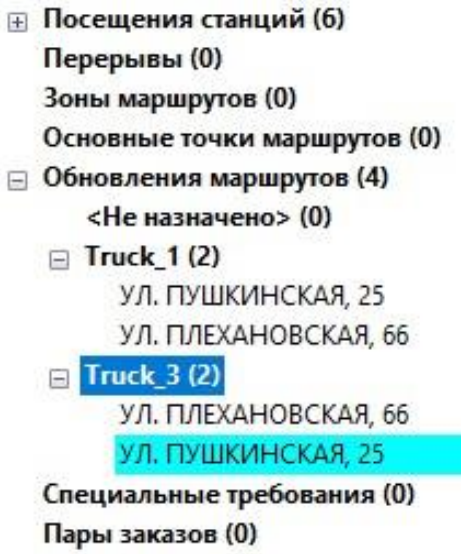


Figure 3.55

In the Network Analyst window, two objects to replenish the load on the route inside the elements Truck_1 and Truck_3 should be displayed (Fig. 3.55).

Change the route to include overtime

To account for overtime, the company intends to eliminate restrictions on maximum time, maximum travel time and maximum distance for routes. Because drivers have to work harder, they will be paid overtime of $ 18 per hour for overtime of 6 hours. In this state, these changes will be made to the routes.

Steps:

1. In the Network Analyst window, on the Routes network analysis class tab, double-click Truck_1.

The Properties window opens.

2. Make changes to the Truck_1 attributes so that they match the values in Table 3.3 and Figure 3.56.

Table 3.3 - Changing attributes

Attribute	Value	Description
1	2	3
(Overtime Start Time)	360	The driver gets overtime if he works for another 6 hours (360 minutes)
(Cost Per Unit Overtime)	0.3	The driver earns $ 18 an hour for overtime. Wages per minute is 18 dollars / 60 minutes = 0.30 cents / minute
(Max Order Count)	20	As the driver gets overtime, he has to go around more shops
(Max Total Time)	<null>	The total working time of the driver is unlimited
(Max Total Travel Time)	<null>	Time in on the road on streets unlimited
(Max Total Distance)	<null>	The total distance traveled by the truck is unlimited

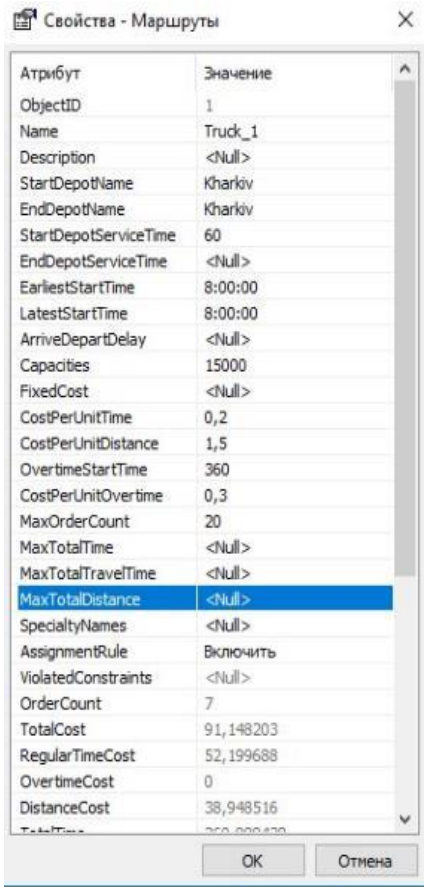


Figure 3.56

3. Click OK.

4. Repeat the last three steps for Truck 3.

Add breaks

Because drivers have to work longer, they will need a half-hour break during the work shift. In this step, you need to define breaks for each route.

Steps:

1. In the Network Analyst window, right-click the Breaks (0) button and select Add Item.

The Properties window opens.

2. Specify the attribute values for the new break, as shown in Table 3.4 and Figure 3.57.

Table 3.4 - Attribute values for the new break

Attributes	Value	Description
1	2	3
(Time Window Start)	12:30 PM	The break should start sometime after 12 o'clock 30 minutes
(Time Window End)	1:30 PM	The break should start somewhere before 13 hours 30 minutes
(Route Name)	Truck_1	Name route, for whose apply this break
(Service Time)	30	Duration of the break in minutes
(Max Violation Time)	0	The break should start between 12 o'clock 30 minutes and 13 hours 30 minutes A value of zero indicates that the break cannot start after 13:30, ie the break time is fixed
(Is Paid)	Truth (True)	This is a paid break, so the costs are included in the total cost of the route

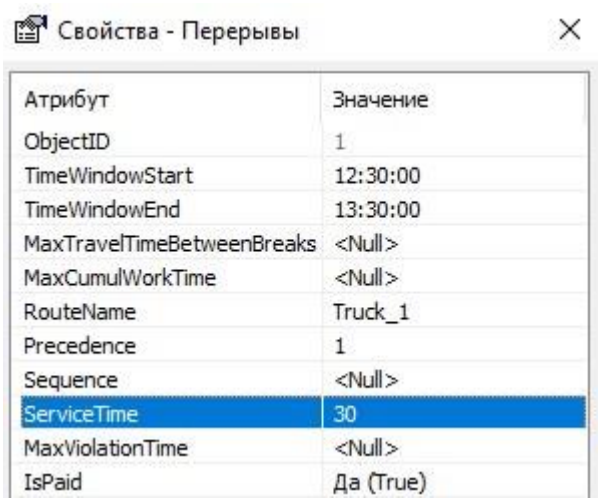


Figure 3.57

3. Click OK.

4. Repeat the last three steps, specifying Truck_3 for the Route Name property.

Now in the Network Analyst window there are two objects specified on the tab of the class Breaks - Truck_1 and Truck_3 (Fig. 3.58).

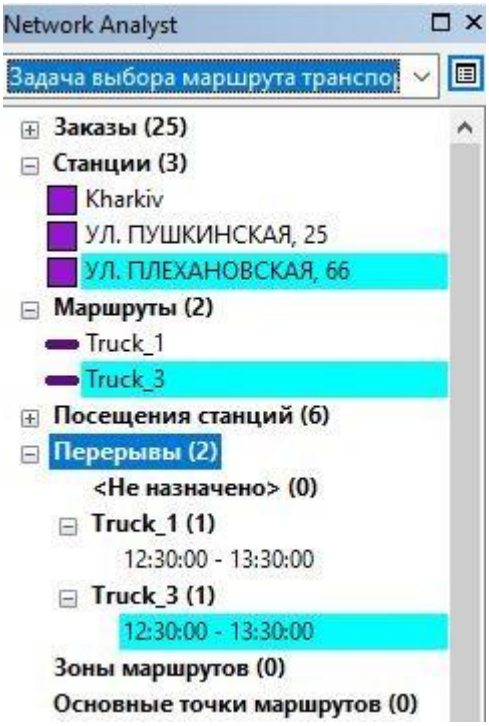


Figure 3.58

Decision making

Click the Solve button Network Analyst toolbar.

The VRP task solution tool calculates two routes that can be used to service orders and draws straight lines connecting orders. Each route starts and ends at the distribution center, serves a set of orders on its way, drives to one recharge center, continues to serve the remaining orders, and finally returns to the distribution center (Fig. 3.59).

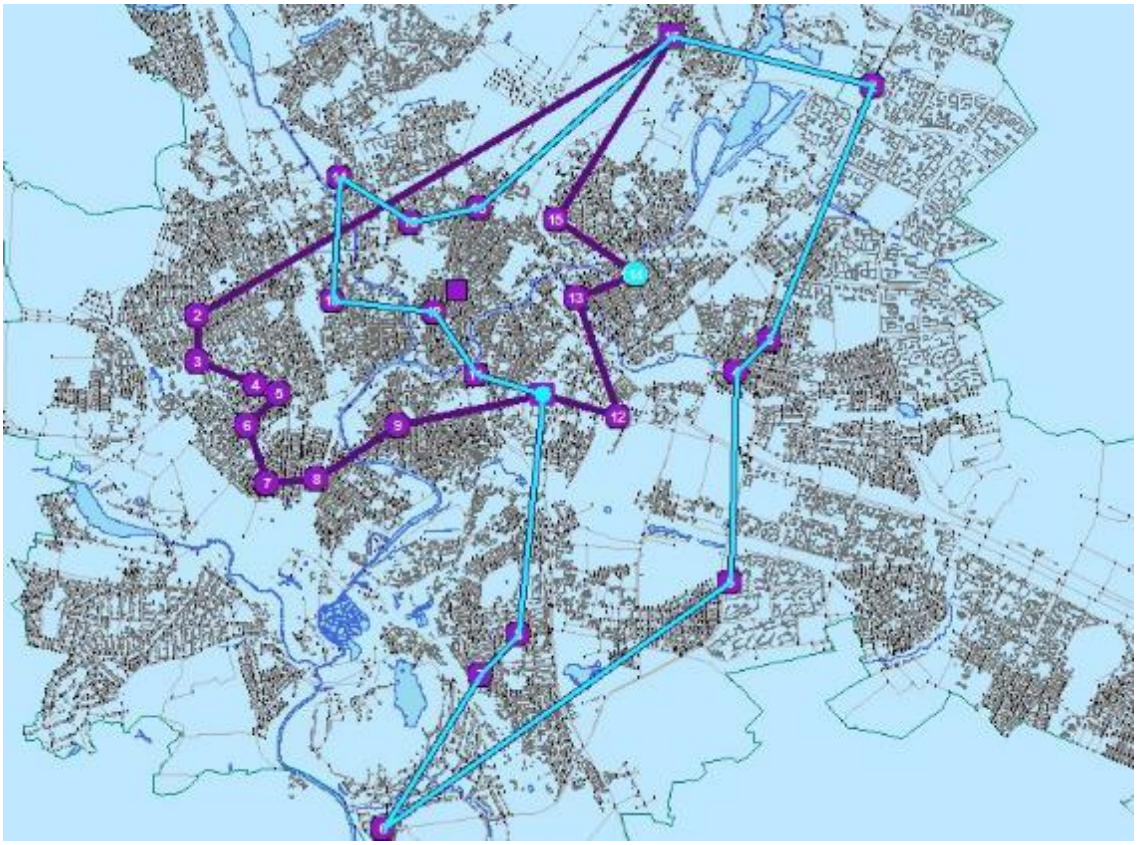


Figure 3.59

This decision coincides with the restrictions specified by the distribution company. However, after issuing travel letters to the two drivers, the company found that the driver of the Truck_1 truck knew the center of Kharkiv better, and the driver of the Truck_3 truck knew the Eastern district better. The company is trying to find a

new solution, which route would serve orders according to the capabilities of drivers. In the next steps, route points will be added that will take into account the wishes of drivers.

Add route starting points

Route starting points for Truck_1 and Truck_3 are determined by geographic address codes. Route exit points can also be imported from an existing feature class or created interactively using the Create Network Location tool.

Steps:

1. In the Network Analyst window, left-click the Route Seed Points button (0). Then click the Find button on the toolbar (Fig. 3.60).

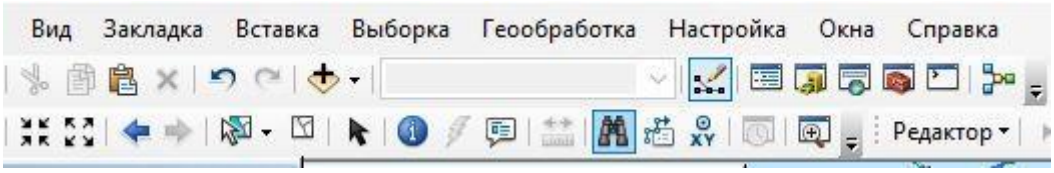


Figure 3.60

The Find dialog box opens.

2. Select the Spatial Objects tab.
3. Select the buildingall layer in the value of B (In) (Fig. 3.61).

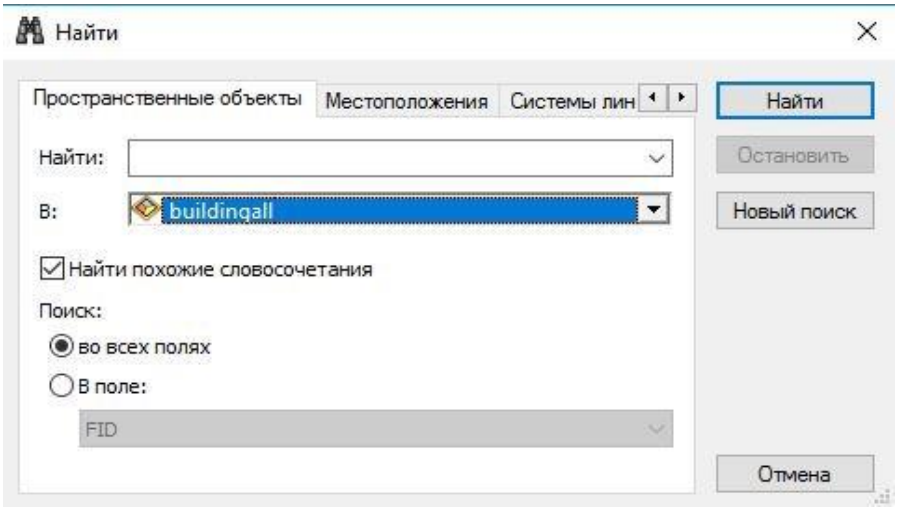


Figure 3.61

4. In the Find text box, enter a street name - Vesnina, 12.

5. Click Find.

6. Right-click on the Find dialog box and select Add as Network Analysis Object.

The new address will be added as the base point of the route to the Network Analyst window and map display.

7. In the Find text box, enter a street name - Klochkivska, 18.

8. Click Find.

9. Right-click the new result at the bottom of the Find dialog box and select Add as Network Analysis Object

10. In the Network Analyst window, double-click on the new main route point - Spring, 12.

The Properties dialog box opens.

11. Specify the attribute values for the route starting point according to Table 3.5 and Figure 3.62.

Table 3.5 - Attribute values for the starting point of the route

Attributes	Value	Description
1	2	3
(Route Name)	Truck_1	Name route, for whose the starting point is used
(Seed Point Type)	Static	As a result of this action, orders near the specified starting point will most likely be assigned to Truck_1

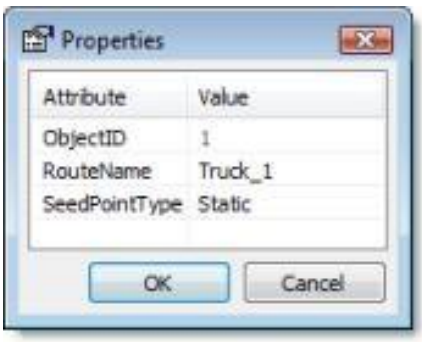


Figure 3.62

12. Repeat steps 1–5 of this section to add the main route points located at Klochkivska, 18.

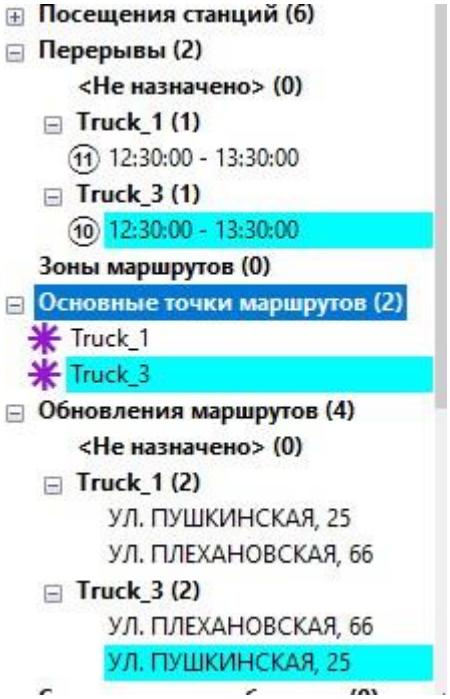


Figure 3.63

13. Repeat steps 6-7 to change the Route Name attribute of the second starting point to Truck_3 (Figure 3.63).

Solution calculation

Click the Solve button Network toolbar Analyst.

The VRP task solution tool calculates two routes that can be used to service orders and draws straight lines connecting orders. The route for Truck_1 provides service only in the center of Kharkiv, and the route for Truck_3 passes through all shops in the Eastern district, as well as through several - in other parts of the city.

3.3 Determining the location of retail facilities using gravity modeling

It is necessary to determine the optimal location of retail facilities to ensure maximum profitability of the retail network [82-83]. The most important thing is to place shopping facilities near the centers of concentration of population and thus ensure demand for goods. Based on this approach, it has been suggested that residents are more willing to shop at nearby stores. You need to analyze the location distribution, using three types of tasks: maximizing attendance, increasing market share and target market. The differences between these types of tasks will become clearer after working out the exercise [84–87].

Preparing the display

Steps:

1. If the Exercise 09.mxd file is open in ArcMap, go to step 6.
2. To start ArcMap, select Start> All Programs> ArcGIS> ArcMap 10.5.
3. In the ArcMap - Getting Started dialog box, click Existing Maps> Browse for more.
4. Navigate to the C: \ ArcGIS \ ArcTutor \ ArcGIS Network Analyst \ Tutorial \ Exercise09 folder.

This is the default location for installing learning materials.

5. Double-click the Exercise 9.mxd file.

The map document will open in ArcMap.

6. Activate the ArcGIS Network Analyst plug-in by running

the following actions:

a) click on Customize> Additional modules (Extensions).

The Extensions dialog box opens;

b) mark ArcGIS Network Analyst;

c) click Close.

If the Network Analyst toolbar doesn't appear, you'll need to add it.

7. Click Customize> Toolbars> Network Analyst.

The Network Analyst toolbar will be added to ArcMap (Figure 3.64).

Figure 3.64

If the Network Analyst window does not appear, you need to add it.

8. On the Network Analyst toolbar, click the Network Analyst window.

The attached Network Analyst window will open (Fig. 3.65).

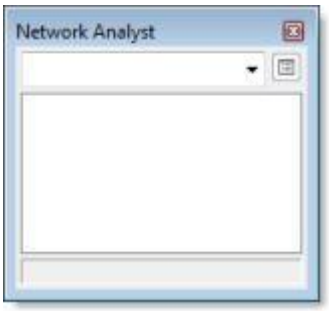


Figure 3.65

The Network Analyst window can be pinned and unpinned.

Create a location analysis layer

Steps:

Click Network Analyst on the Network Analyst toolbar and New Location-Allocation

(Fig. 3.66).

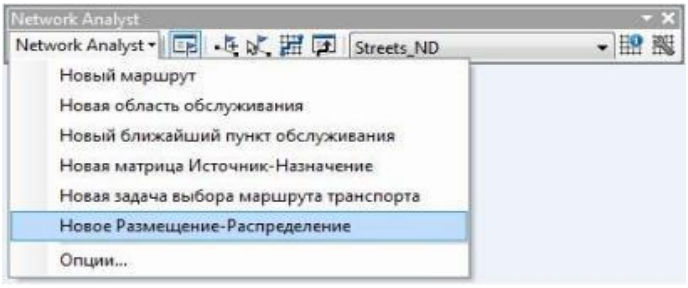


Figure 3.66

The Location-Distribution Analysis layer has been added to the Network Analyst window. Network Analysis Classes: Facilities, Demand Points, Lines, Point Barriers, Line Barriers, and Polygon Barriers - Empty (Fig. 3.67).

Figure 3.67

A new layer of analysis has also been added to the Table Of Contents window (Fig. 3.68).

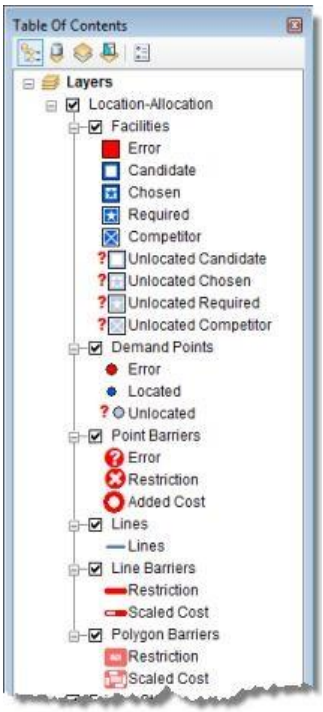


Figure 3.68

Adding potential objects

It is necessary to add potential locations of trade objects to the class of analysis of the network of Objects. There are potential places where you can open a store. The decision in the process of placement-distribution involves the selection of these retail facilities.

The location of potential trade objects has already been added as the Candidate Object layers to the map document. Store names are contained in the layer attribute table. Let's load point objects from Potential trade objects in the object class of the placement-distribution layer.

Steps:

1. In the Network Analyst window, right-click the button Facilities (0) and select Load Locations.

The Load Locations dialog box opens.

2. Select Potential Trade Objects (CandidateObject) from the Load From list (Fig. 3.69).

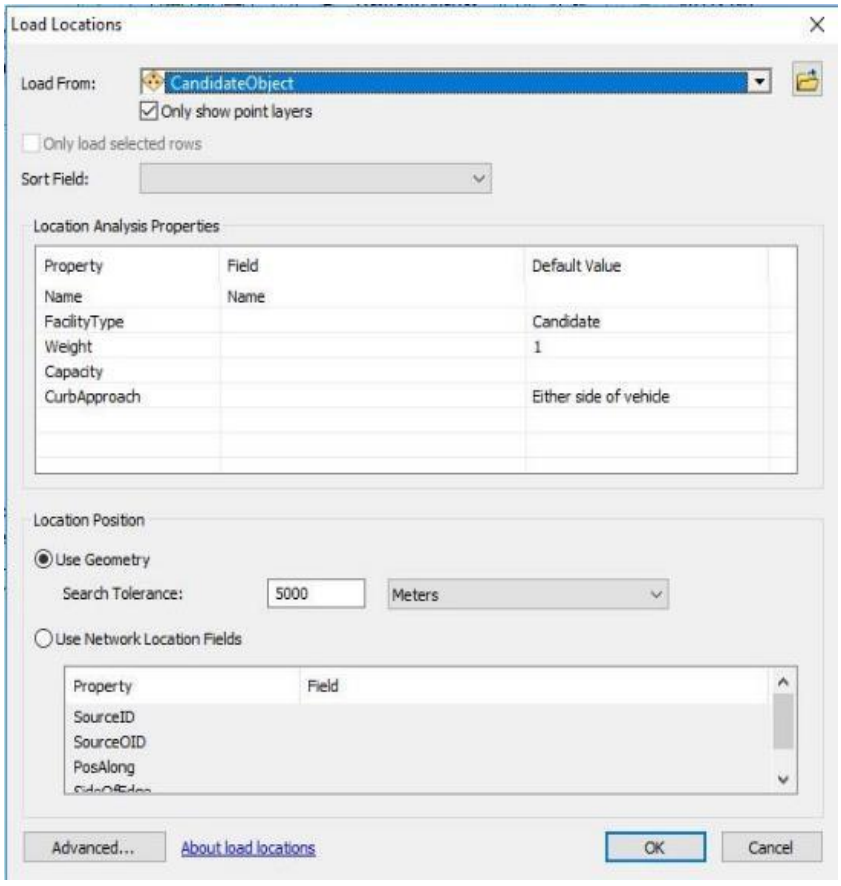


Figure 3.69

The Location Analysis Properties section of the Load locations dialog box allows you to specify which attributes of the Potential Trade Objects class contain the values that Network Analyst will use when solving the placement-distribution task.

3. In the Location Analysis Properties section, make sure that the Name property automatically matches the NAME field.

Network Analyst tries to automatically associate location analysis properties for a new placement-distribution task layer using a configuration file (usually located in the ArcGIS installation folder in: \ Program Files \ ArcGIS \ Desktop10.5 \ NetworkAnalyst \ NetworkConfigurations \ NASolverConfiguration.xml).

4. Click OK.

16 potential trade objects are loaded into the network analysis class Objects. New trade objects are contained in the Network Analyst window and are displayed on the map (Fig. 3.70).

Figure 3.70

Adding demand points

Shopping facilities should be located as convenient as possible for the population. A point layer of centroids of adjacent census quarter groups has already been added to ArcMap. You need to load these centroids into the Demand points network analysis class.

Steps:

1. In the Network Analyst window, right-click the Demand Points (0) button and select Load Locations.

2. Select Tract Centroids from the Load From list.

3. In the Location Analysis Properties section, make sure that the Name property automatically matches the NAME field.

4. Click the Field column for the Weight property and select POP2000.

Each point of demand is estimated by population according to the 2016 census (Fig. 3.71).

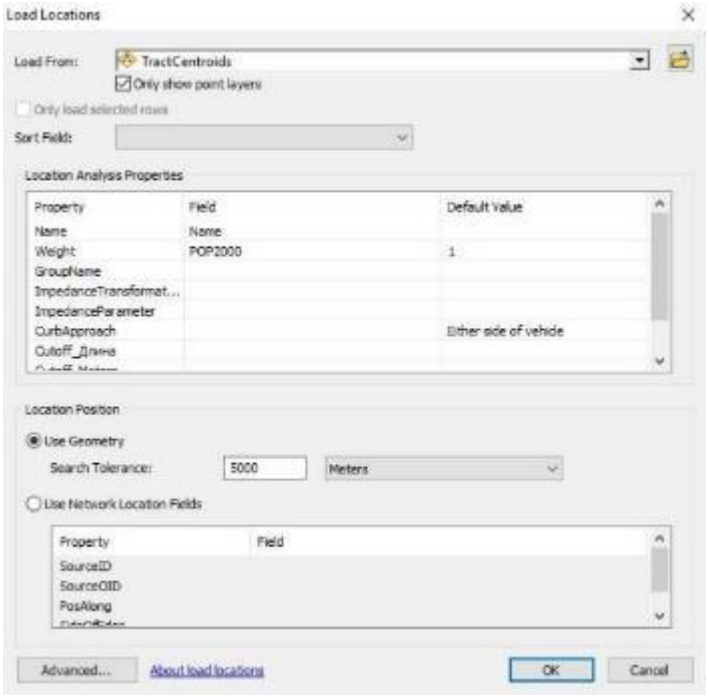


Figure 3.71

5. Click OK.

208 centroids from adjacent census groups are loaded into the Demand Points class. The new demand points are indicated in the Network Analyst window and displayed on the map (Fig. 3.72).

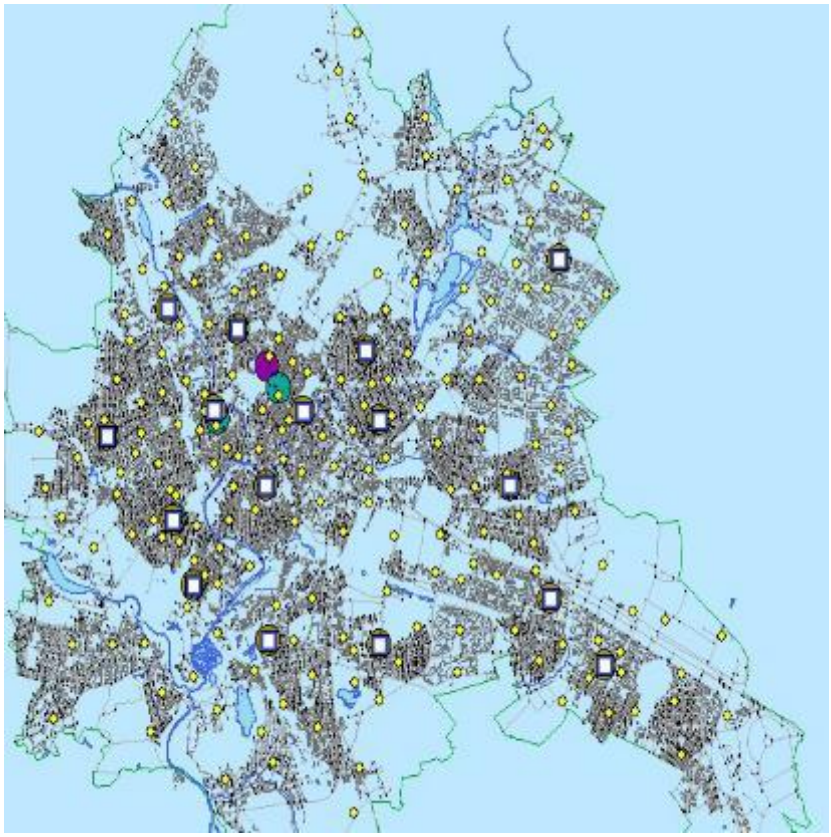


Figure 3.72

Establish properties of location-distribution analysis

Steps:

1. Click the Analysis Layer Properties button in the Network Analyst window (Fig. 3.73).

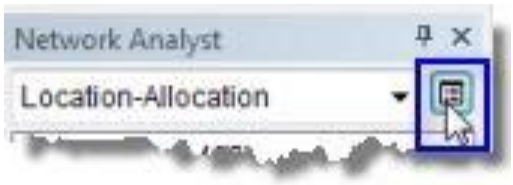


Figure 3.73

The Layer Properties dialog box opens.

2. Click the Analysis Settings tab.
3. Make sure Impedance is defined as Travel Time (Minutes).
4. Do not select Use Start Time.

If you want to calculate the location-distribution based on traffic at certain hours and days of the week, enter the start time here.

5. In the Travel From section, specify Demand to Facility.

The Default Facility to Demand option is optimal for classic impedance minimization and coverage maximization tasks. However, in the task of increasing attendance, increasing market share and target market, demand usually shifts to objects, so the choice from Demand to Facility is mostly good for such cases.

6. Select Allowed from the U-Turns at Junctions drop-down list.

7. In the Output Shape Type section, set the Straight Line. Although the source data is displayed as straight lines, the cost of moving is first measured over the network.

8. Make sure Ignore Invalid Locations is checked.

9. Make sure Restricted Turns and One way are highlighted in the Restrictions section.

The Analysis Settings tab should look like this (Figure 3.74).

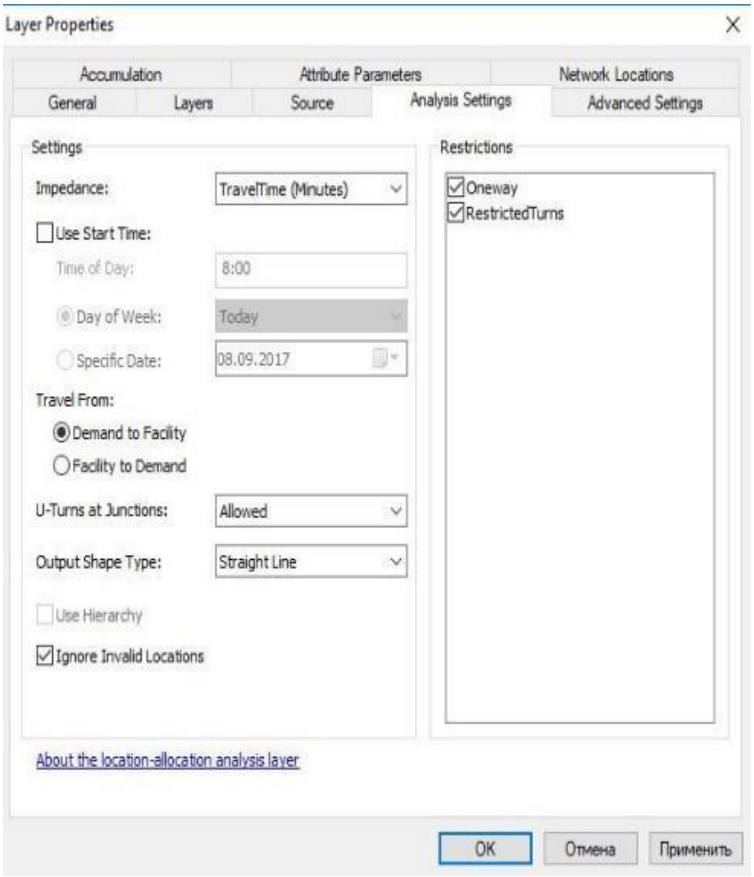


Figure 3.74

10. Select the Advanced Settings tab.

11. Click the Problem Type drop-down list and select element Software maximum attendance (Maximize Attendance).

These types of tasks are usually used as an example. Ensuring maximum attendance is the best type of task for the location of retail outlets, as it is assumed that all outlets are equally attractive, and people are more willing to buy goods in stores located nearby.

12. Select the number 3 in the Facilities To Choose window.

ArcGIS will select three objects out of 16 that best serve 208 demand points.

13. Select the number 5 in the Impedance Cutoff window.

This setting means that people do not want to go to the store for more than five minutes. The unit of measurement for this value is determined by the unit of measurement of the impedance attribute. Because Travel Time is measured in minutes, this value is also given in minutes.

14. Make sure that Impedance Transformation is set to Linear. ArcGIS will use a linear relationship when calculating the probability of visiting a particular store. Therefore, if the impedance limit of five minutes and the linear impedance conversion are applied, the probability of visiting a trade object decreases by 1/5, or 20% every minute, ie a trade object located one minute from the point of demand has the probability of visiting is 80%, in contrast to the shopping facility located four minutes away, for which the probability is only 20%.

15. Click OK.

The process of finding the best location of shopping facilities

Steps:

1. Click the Solve button Network Analyst toolbar solution.

At the end of the process, lines will appear on the map connecting the selected retail outlets with points of demand. Lines will also be displayed in the Lines class in the Network Analyst window (Fig. 3.75).

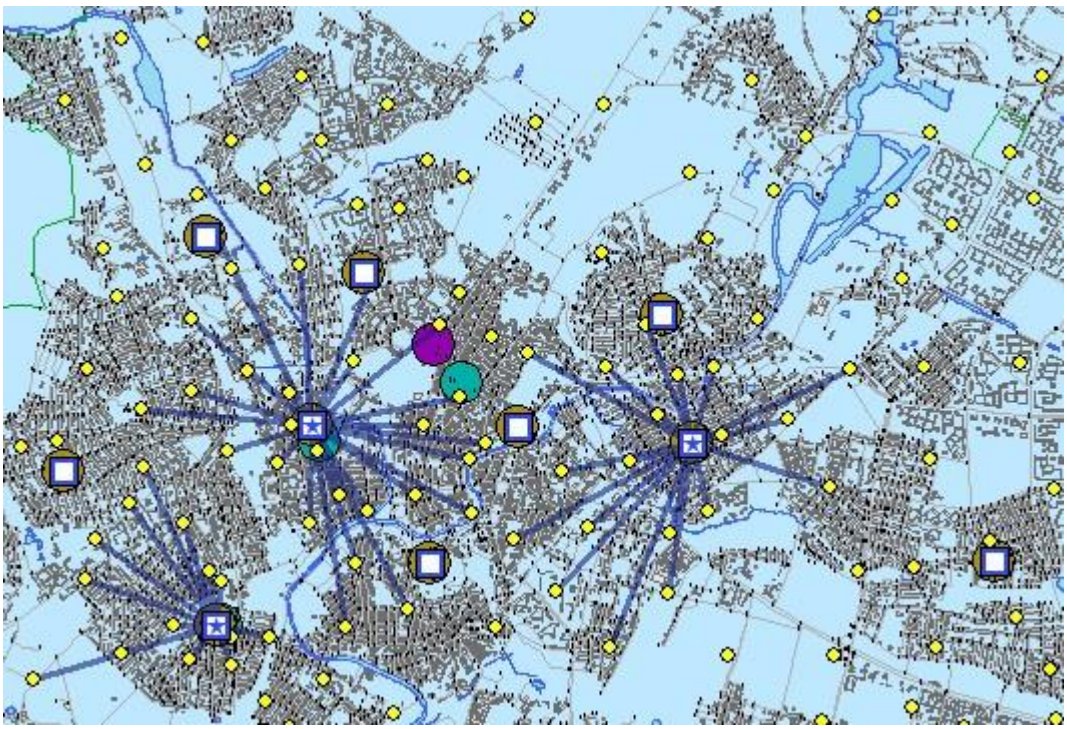


Figure 3.75

Now you can read the results in more detail.

2. In the Table Of Contents, right-click on the Facilities sublayer and select Open Attribute Table (Figure 3.76).

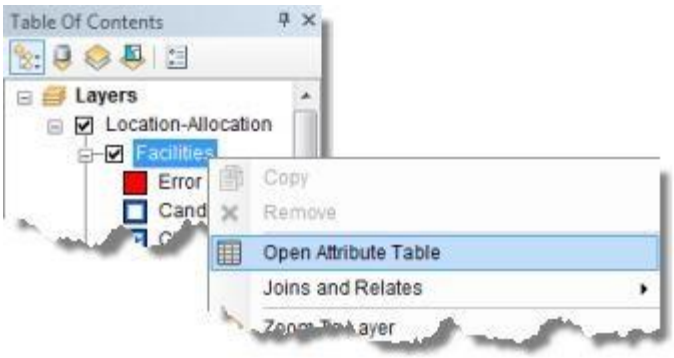
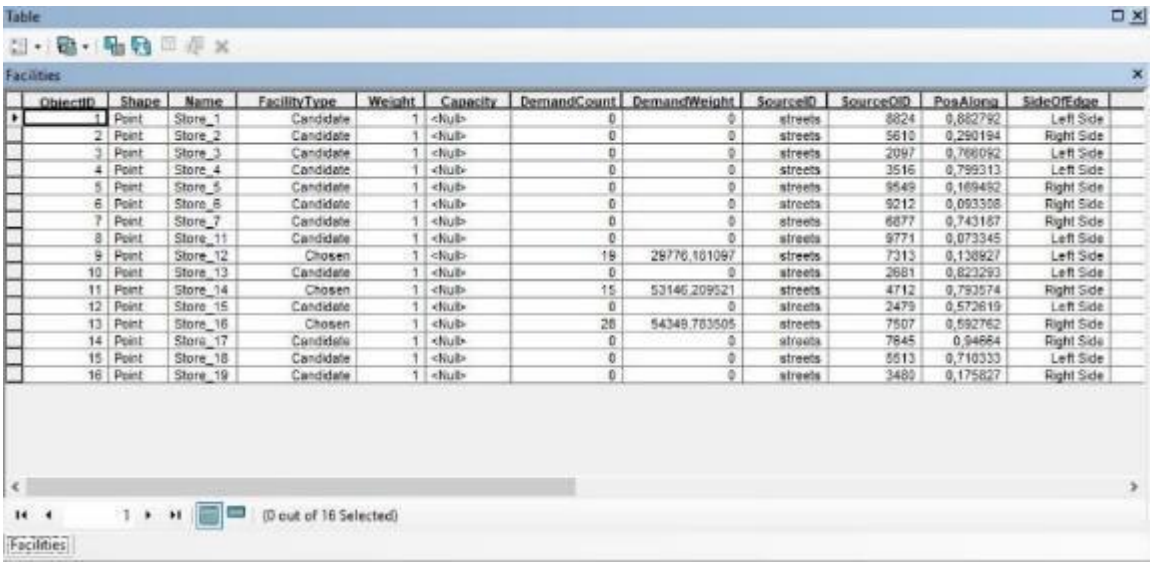


Figure 3.76

3. Check the attributes in the object table. The value of the three objects in the FacilityType field is set to Chosen instead of the default Candidate setting (Fig. 3.77).



ObjectID	Shape	Name	FacilityType	Weight	Capacity	DemandCount	DemandWeight	SourceID	SourceOID	PosAlong	SideOfEdge
1	Point	Store_1	Candidate	1	<Null>	0	0	streets	8824	0,882792	Left Side
2	Point	Store_2	Candidate	1	<Null>	0	0	streets	5610	0,290194	Right Side
3	Point	Store_3	Candidate	1	<Null>	0	0	streets	2097	0,766092	Left Side
4	Point	Store_4	Candidate	1	<Null>	0	0	streets	3516	0,799313	Left Side
5	Point	Store_5	Candidate	1	<Null>	0	0	streets	9549	0,169492	Right Side
6	Point	Store_6	Candidate	1	<Null>	0	0	streets	9212	0,093308	Right Side
7	Point	Store_7	Candidate	1	<Null>	0	0	streets	6877	0,743187	Right Side
8	Point	Store_11	Candidate	1	<Null>	0	0	streets	9771	0,073345	Left Side
9	Point	Store_12	Chosen	1	<Null>	19	28776,101097	streets	7313	0,138927	Left Side
10	Point	Store_13	Candidate	1	<Null>	0	0	streets	2681	0,823293	Left Side
11	Point	Store_14	Chosen	1	<Null>	15	53146,209521	streets	4712	0,793574	Right Side
12	Point	Store_15	Candidate	1	<Null>	0	0	streets	2479	0,572619	Left Side
13	Point	Store_16	Chosen	1	<Null>	28	54349,783505	streets	7507	0,592762	Right Side
14	Point	Store_17	Candidate	1	<Null>	0	0	streets	7845	0,94664	Right Side
15	Point	Store_18	Candidate	1	<Null>	0	0	streets	6513	0,710333	Left Side
16	Point	Store_19	Candidate	1	<Null>	0	0	streets	3480	0,175827	Right Side

Figure 3.77

The Demand Count column lists the demand points assigned to each of the selected objects. We must not forget that out of 208 demand points, only 62 were distributed among the selected objects, as others were located more than five minutes from them.

The Demand Weight column shows the demand value for each item. In this case, the value is the number of people who will mainly buy goods in this store.

4. Close the Facilities table.

5. In the Table Of Contents, right-click on the Demand Points sublayer and select Open Attribute Table (Figure 3.78).

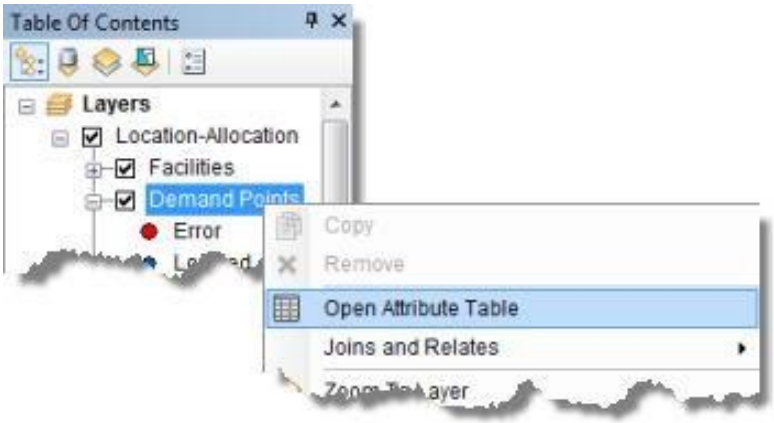


Figure 3.78

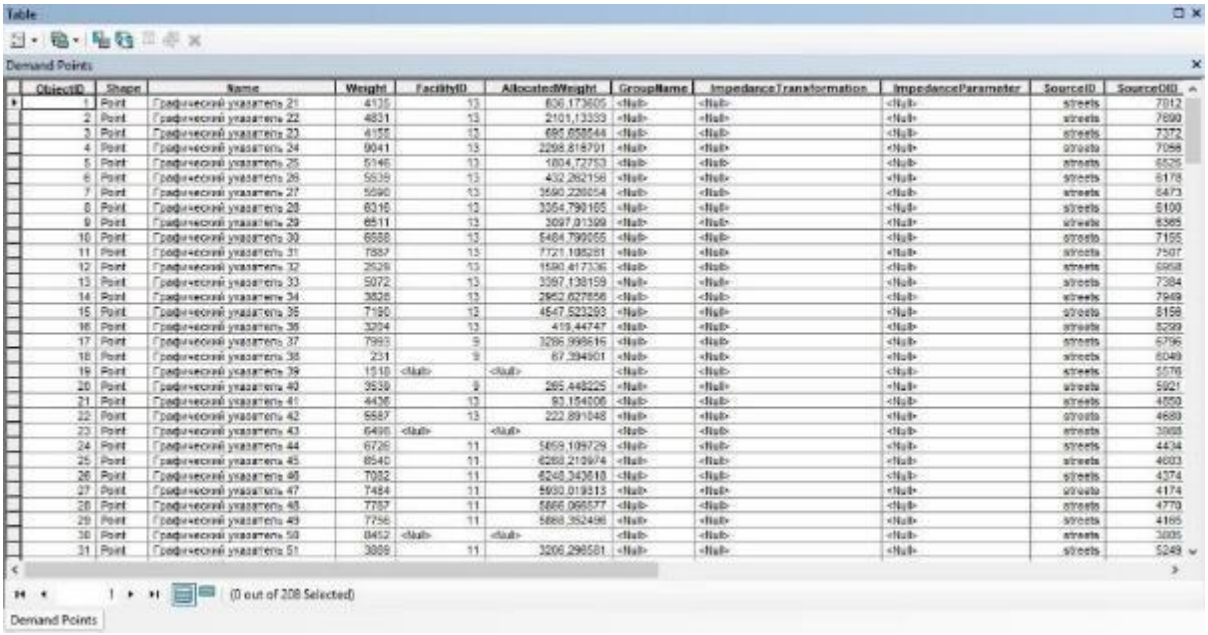


Figure 3.79

6. Check the attributes in the table of demand points (Fig. 3.79). If the point of demand is less than five minutes from the object, the Facility ID column is set to <Null>, the other value in this column is the identifier of the selected object to which belongs to the point of demand.

The Weight column shows the number of inhabitants loaded from the Census tract. The Allocated Weight column shows the demand for a particular service point. The weight allocated to a particular service point is calculated based on the linear reduction in demand during the removal process and the five-minute impedance limit set in the Layer Properties dialog box.

7. In the Table Of Contents, right-click on the Lines sublayer and select Open Attribute Table (Figure 3.80).

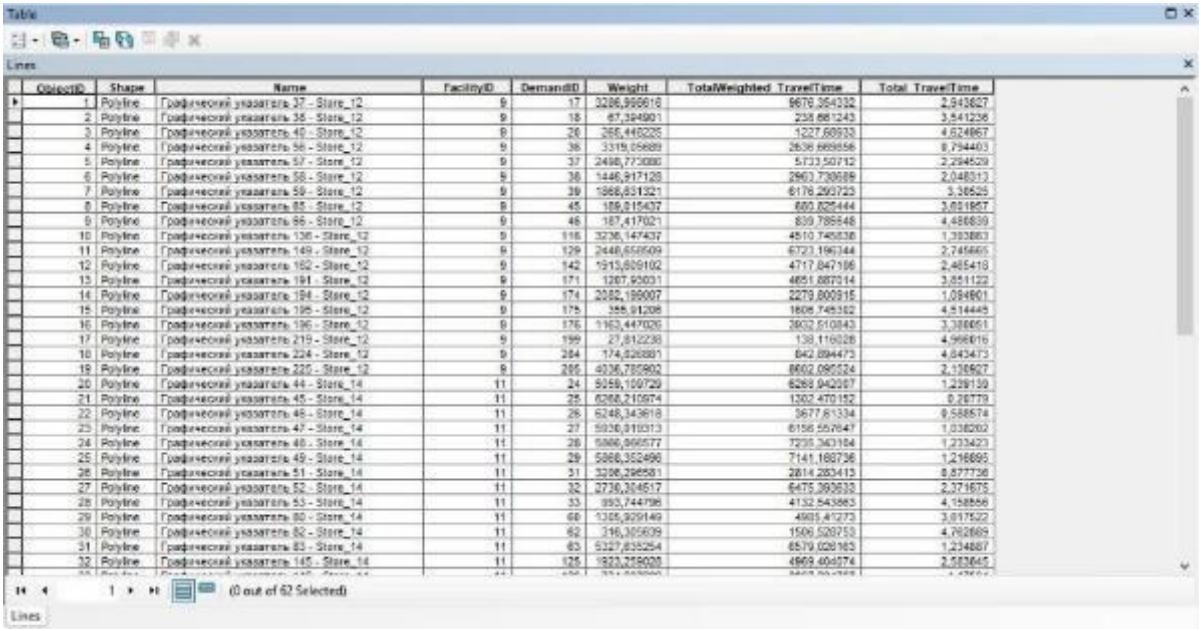


Figure 3.80

The table shows one record for each point of demand assigned to a particular object. It also indicates the impedance of the shortest path between two objects and the weight accounted for by each object.

8. Close the attribute table.

Add the required object

So, where you need to locate three new retail facilities, determined. Next, we consider the process of expansion of a retail facility using the method of placement-distribution, when one retail facility already exists, and you need to better place two more.

Steps:

1. In the Network Analyst window, right-click the button Facilities (16) and select Load Locations.

The Load Locations dialog box opens.

2. Select Existing Object from the Load From list.

3. In the Location Analysis Properties section make sure the Name property matches the NAME field.

4. In the Default Value column for the Facility Type, replace Candidate with Required.

After loading the trade object, it will have the status Required. Mandatory objects are an integral part of the solution (Fig. 3.81).

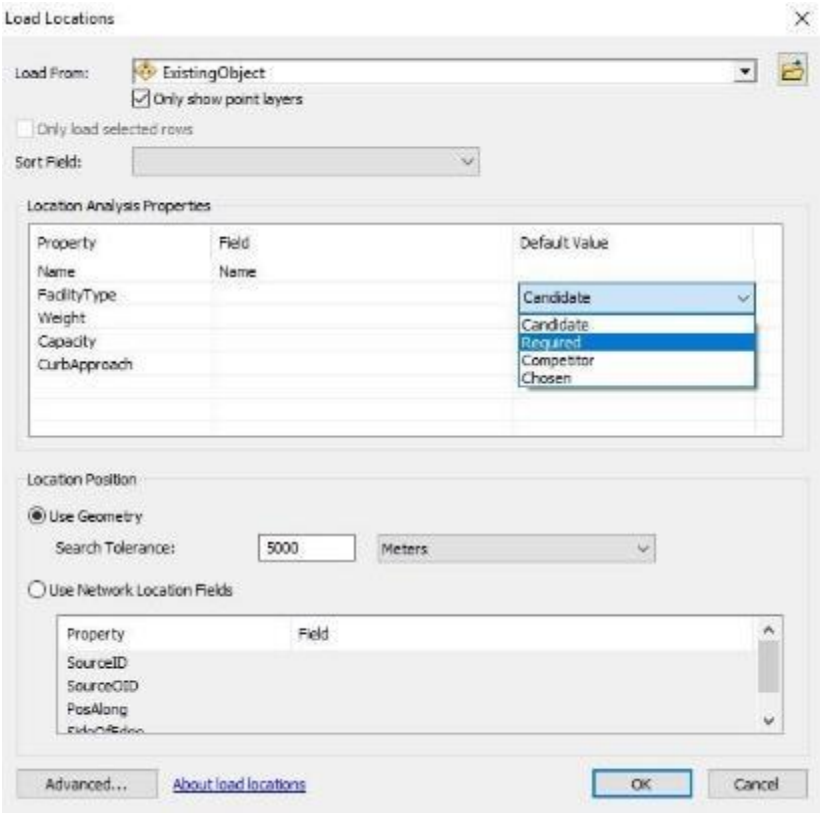


Figure 3.81

5. Click OK.

Establishing the properties of the analysis (ensuring maximum attendance with the selection of the required object)

To solve this problem, use the same properties as in the previous section.

Steps:

1. Click the Analysis Layer Properties button in the Network Analyst window (Fig. 3.82).

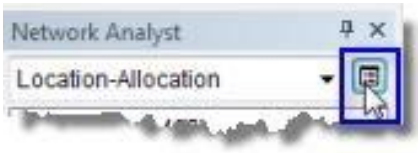


Figure 3.82

The Layer Properties dialog box opens.

2. Make sure the Maximize Attendance task type is set, the number of objects searched is 3, the impedance limit is 5, and the impedance conversion is set to Linear.

3. Click OK.

The process of determining the optimal location of retail facilities (ensuring maximum attendance with the choice of mandatory facility)

Click the Solve button Network Analyst toolbar.

At the end of the process, the selected retail outlets will be connected to the demand points by lines. We must remember that the original solution has changed and the ExistingObject is part of the solution (Fig. 3.83).

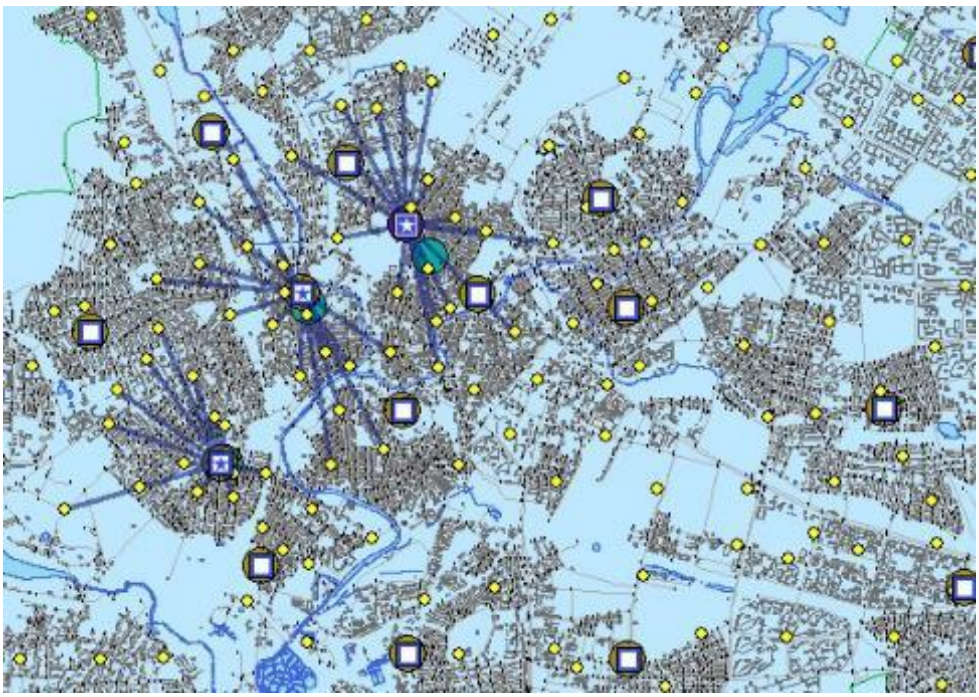


Figure 3.83

Adding competing objects

The placement-distribution calculation mechanism allows you to place new retail outlets to increase market share given the presence of competitors. Market share is calculated using the Huff model, or gravity model. Huff's model assumes that the probability of visiting retail outlets by demand points is determined by some properties of these retail outlets, as well as the distance to them.

Steps:

1. In the Network Analyst window, right-click the button Facilities (17) and select Load Locations.
2. Select Competitor Object from the Load From list.
3. In the Location Analysis Properties section make sure what property Name automatically matches the NAME field.
4. In the Default Value column for the Facility Type, replace the Candidate with the Competitor (Figure 3.84).

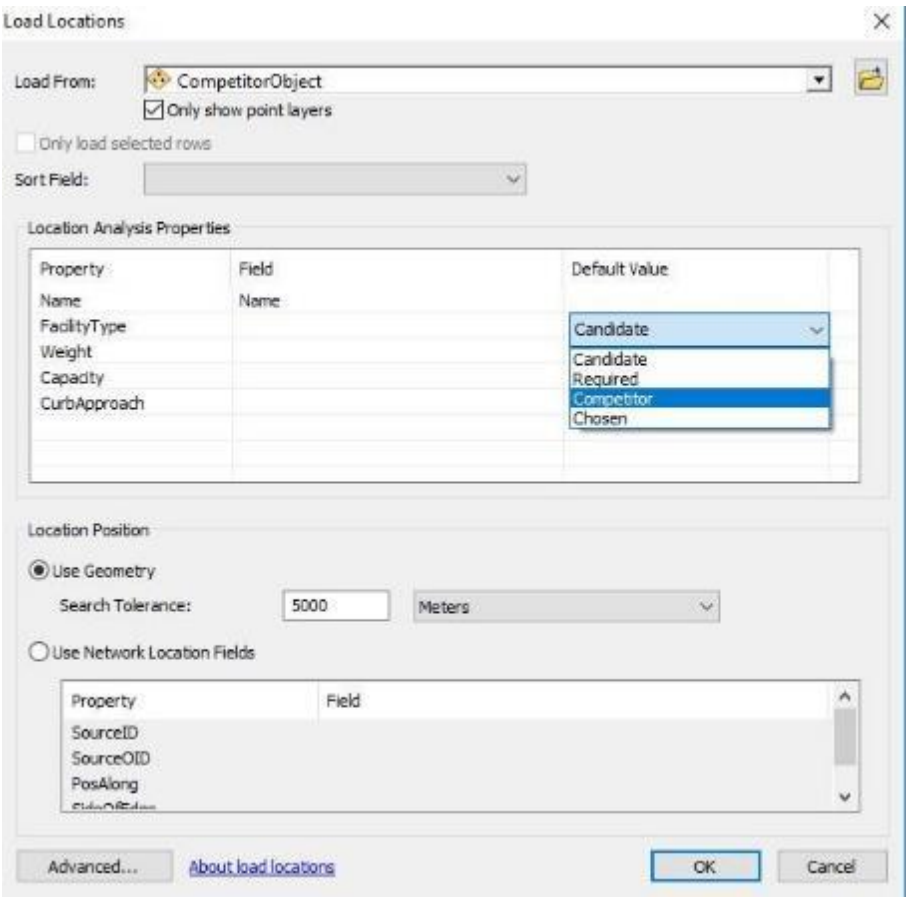


Figure 3.84

5. Click OK.

6.

Establishing the properties of the analysis (ensuring maximum market share)

You need to change the properties of the placement-distribution analysis layer so that they can be used to solve a Maximize Market Share task.

Steps:

1. Click the Analysis Layer Properties button in the Network Analyst window (Fig. 3.85).

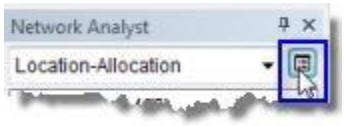


Figure 3.85

The Layer Properties dialog box opens.

2. Select the Advanced Settings tab.

3. Click the Problem Type drop-down list and select Maximize Market Share.

4. Click the Impedance Transformation drop-down list and select Power.

ArcGIS will be use degree dependence in the process of determining the probability of visiting a particular retail facility. We must remember that Impedance Parameter can be edited.

5. Change the value of the Impedance Parameter to 2.

The impedance parameter 2 under the condition of impedance transformation means that the probability of visiting a trade object decreases in proportion to the square of the distance between the points of demand and the location of the object. Typically, the exact value of the impedance parameter is calculated using other analysis tools, such as ArcGIS Business Analyst.

6. Click OK.

The process of determining the optimal location of retail facilities (ensuring maximum market share)

Steps:

1. Click Network Analyst on the Network Analyst toolbar and Options.

The ArcGIS Network Analyst Options dialog box opens (Figure 3.86).

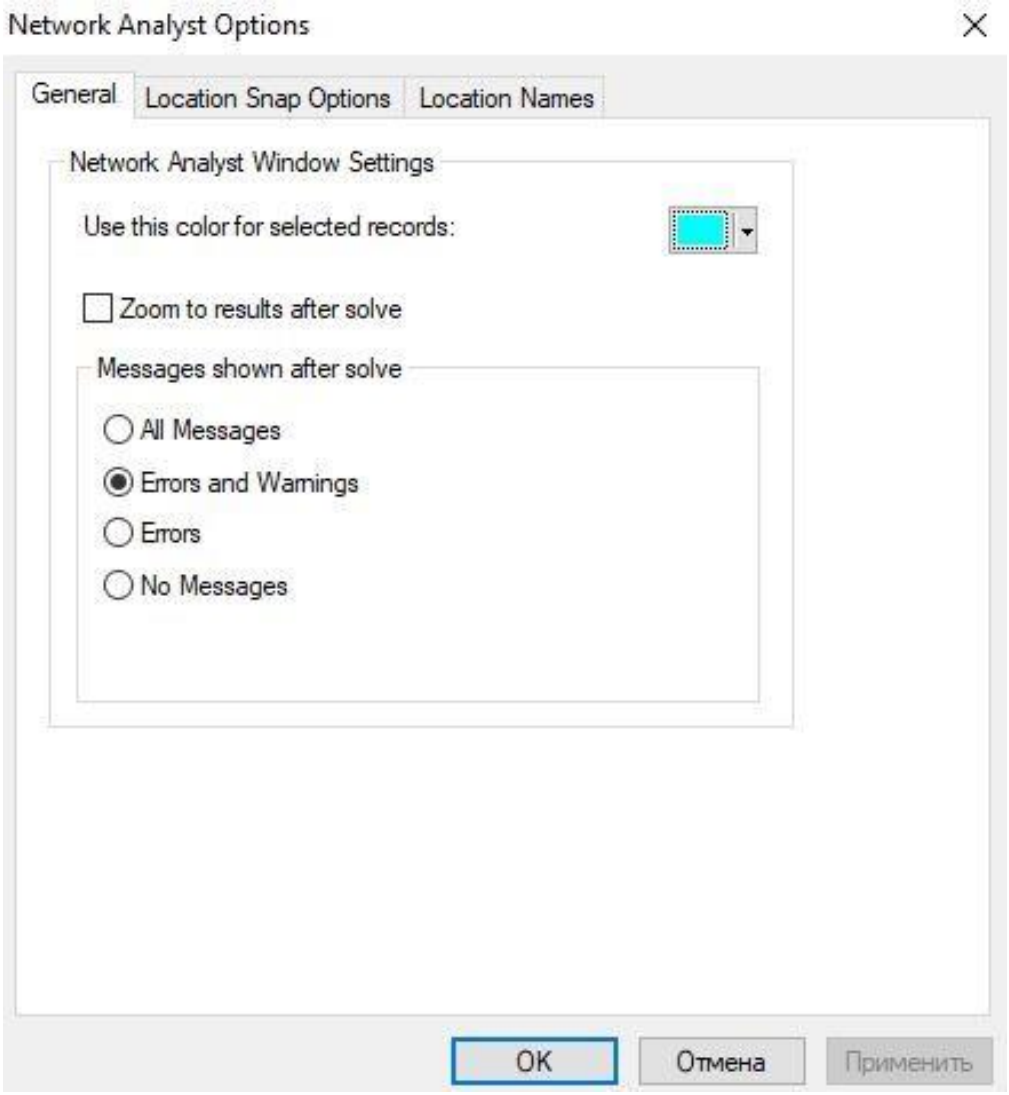


Figure 3.86

2. Click the General tab.
3. Select All Messages.

If you select the All Messages command in the tasks to ensure the maximum market share, the obtained market share will be displayed in the dialog box after the process is completed.

4. Click OK.

5. Click the Solve button Network Analyst toolbar.

Upon completion of the process, a special notice will indicate the market share.

6. Close the message.

Demand points are connected on the map by lines with selected retail outlets and competitors. It should be remembered that the selected retail outlets have been changed to ensure maximum demand in the case of three competitors.

The lines overlap more than in the previous decision, because each point of demand in the task of ensuring maximum market share can interact with all objects in the impedance zone.

7. In the Table Of Contents, right-click on the Objects sublayer and select Open Attribute Table (Figure 3.87).

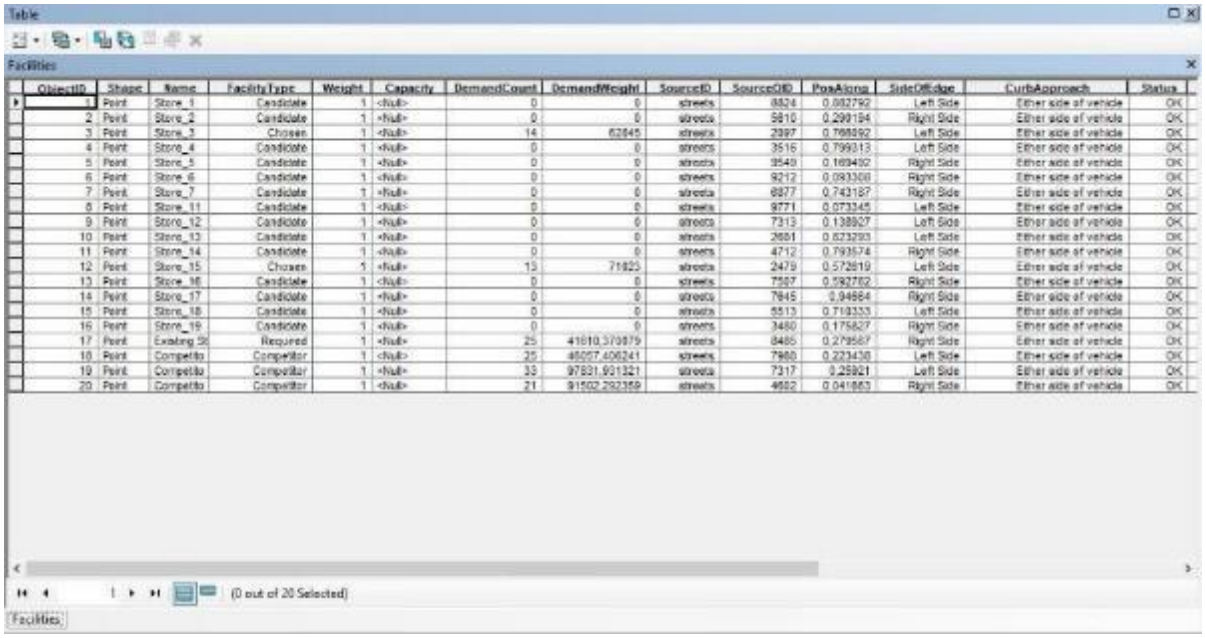


Figure 3.87

For three objects, the Facility Type section is set to Competitor: one is Required and two are Chosen, which is the best calculation mechanism.

The Demand Count column lists the demand points assigned to each object. It should be remembered that some demand points are not taken into account because they are located outside the five-minute impedance zone.

The Demand Weight column shows the amount of demand for each selected object. The importance of stores, compared to the importance of competitors, makes it possible to single out the market share identified as a result of the decision.

8. Close the attribute table.

Increasing target market share

It is established that the total market share for the three selected retail outlets is 18.20%. Assume that you need to reach a market share of 65%. To do this, you need to determine the minimum number of retail facilities required for this, and their preferred location. The task of increasing the target market share will help answer this question.

Steps:

1. Click the Analysis Layer Properties button in the Network Analyst window (Fig. 3.88).

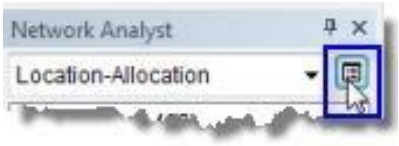


Figure 3.88

The Layer Properties dialog box opens.

2. Select the Advanced Settings tab.

3. Click the Problem Type drop-down list and select Target Market Share.

4. Keep in mind that if you change the task type to Increase Target Market Share, the Target Market Share (%) property will be editable.

Change the Target Market Share property (%) to 65.

5. Click OK.

Determining the optimal location of retail facilities (increase in target market share)

Steps:

1. Click the Solve button Network Analyst toolbar.

Upon completion of the decision process, a special message will indicate the target market share and the number of retail outlets needed to achieve it. The target market share is more than 65%, because if a smaller number of retail outlets were opened, the target market share would be less than the required 65%.

2. Close the message.

Solution objects are connected on the map with demand points using lines.

3. In the Table Of Contents, right-click on the Facilities sublayer and select Open Attribute Table (Figure 3.89).

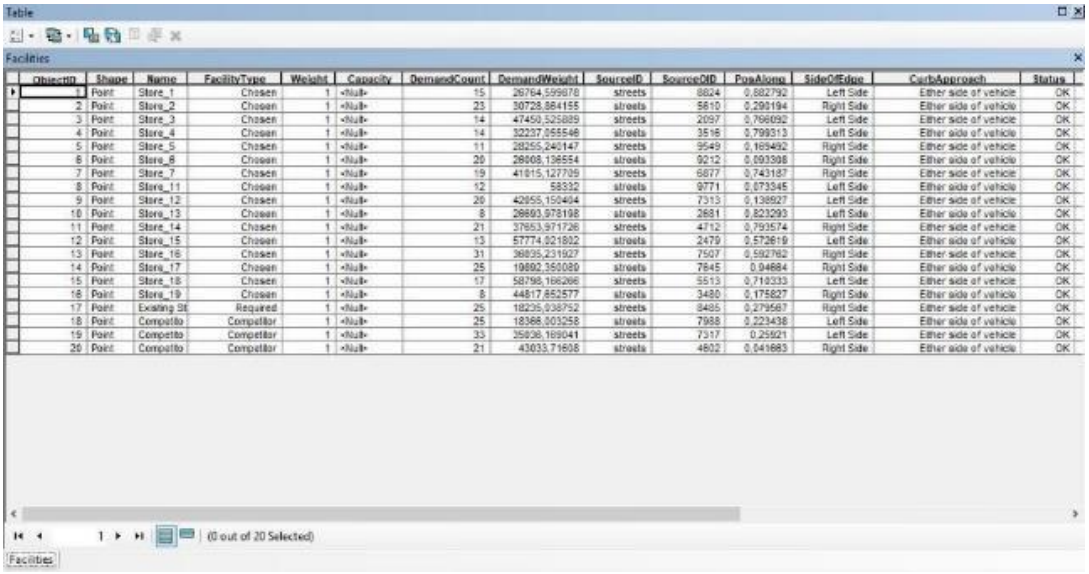


Figure 3.89

In addition to the three competing trade objects and one obligatory trade object, sixteen trade objects have been created, the Facility Type of which is Chosen. Thus, to achieve the target market share of 65% requires sixteen additional retail outlets.

4. Exit ArcMap. Click No to save the changes.

CONCLUSIONS

The possibility of using geoinformation technologies for modeling transport networks has been established. The possibility of creating multimodal sets of network data that provide planning of transport activities using multiple networks is proved.

Scientific and practical approaches to determining the impact of road networks on the basic indicators of the functioning of transport systems are studied. In the environment of modern information technologies to determine the basic characteristics of the road network of Ukraine used methods of network analysis.

Scientific approaches to modeling the parameters of long-distance passenger connections are studied. It is determined that driving time affects the indicators of passenger transport correspondence as a factor of resistance to potential correspondence. This determines the importance (necessity) of determining the potential coverage of cities as transport hubs for the full period of time in the models of road networks.

According to the results of the simulation of landfills with maximum passenger route transport accessibility for different modes of transport, it was found that the characteristics of the simulated set of landfills are influenced by the selected network model and connection speed. It is proved that at the same speed the polygons built in different networks differ. This is due to the individual characteristics of networks, which in each case are described by the pattern and number of links in the network.

According to the results of the analysis of the current state of development of scientific approaches and methods of improving urban transport systems, there is a need to apply integrated approaches to the organization of transportation.

The main directions of development of traffic management systems are determined. It is established that the most effective today are Automated Control Systems (Intelligent Transport System) and integrated into transport information.

The possibility of using geographic information systems on the organization, planning and calculation of planned indicators of transport operation while taking into account multifactorial constraints is considered.

Gravitational modeling was used to analyze the location of objects. The provision of a comprehensive analysis of the object and a set of many factors and their interaction, which increases with the development of commercial real estate and increased competition.

The model format of research allows making a decision on the implementation of the project at the pre-project stage, without spending effort and resources to develop the concept of future objects. The study simulates the location of retail facilities in the network using a gravity model (Huff model) on the example of Kharkiv.

REFERENCES

1. Dolya V. (2011). Pasazhyrski perevezennia. Kharkiv: Fort, 503.
2. Aparicio A. Exploring the sustainability challenges of long-distance passenger trends in Europe // Transportation Research Procedia / A. Aparicio. 2016. - Vol. 13. - P. 90–99.
3. Arhin et al S. Optimization of transit total bus stop time models // Journal of Traffic and Transportation Engineering (English Edition) - 2016. - V. 3. - № 2. - P. 146–153.
4. Forecasting model for air taxi, commercial airline, and automobile demand in the United States // Transportation Research Record: Journal of the Transportation Research Board / H. Baik et al. - 2008. - № 2052. - P. 9–20.
5. A flexible transportation service for the optimization of a fixed-route public transport network // Transportation Research Procedia / I. Bakas et al. - 2016. - V. 14. - P. 1689–1698.
6. Bohari ZA Improving the Quality of Public Transportation System: Application of simulation model for passenger movement // Procedia-Social and Behavioral Sciences / ZA Bohari, S. Bachok, MM Osman. - 2014. - V. 153. - P. 542–552.
7. Modeling public transport route choice, with multiple access and egress modes // Transportation research procedure / T. Brands et al. - 2014. - Vol. 1. - № 1. - P. 12–23.
8. Integrating public transport into mobiTopp // Future Generation Computer Systems / L. Briem et al. - 2017
9. Dave SM Modeling trip attributes and feasibility study of co-ordinated bus for school trips of children // Procedia-Social and Behavioral Sciences / SM Dave, DP Raykundaliya, SN Shah. - 2013. - V. 104. - P. 650–659.
10. Deri A. Efficient Usage of Transfer based System in Intracity Bus Transit Operation: Sample of Izmir // Procedia-Social and Behavioral Sciences / A. Deri, A. Kalpakci. - 2014. - V. 111. - P. 311–319.

11. A multimodal transport network model and efficient algorithms for building advanced traveler information systems // Transportation Research Procedia / O. Dib et al. - 2017. - V. 22. - P. 134–143

12. Essadeq I. Modeling. Passenger Congestion in Transit System-Benchmark and Three Case Studies // Transportation Research Procedia / I. Essadeq, E. Dubail, E. Jeanniere. - 2016. - V. 14. - P. 1792–1801.

13. Fonzone A. A model of bus bunching under reliability-based passenger arrival patterns // Transportation Research Part C: Emerging Technologies / A. Fonzone, JD Schmöcker, R. Liu. - 2015. - V. 59. - P. 164–182.

14. The Model of Correspondence of Passenger Transportation on the Basis of Fuzzy Logic // ECONTECHMOD: an international quarterly journal on economics of technology and modeling processes / Y. Fornalchyk, A. Bilous, I. Demchuk. - 2015. - Vol. 4.

15. Grosche T. Gravity models for airline passenger volume estimation // Journal of Air Transport Management / T. Grosche, F. Rothlauf, A. Heinzl. - 2007. - V. 13. - № 4.– P. 175–183.

16. Haar S. A hybrid-dynamic model for passenger-flow in transportation systems // IFAC-PapersOnLine / SA Haar, S. Theissing. - 2015. - V. 48. - № 27. - P. 236–241.

17. Public Transport Systems' Connectivity: Spatiotemporal Analysis and Failure Detection // Transportation Research Procedia / Y. Hadas et al. - 2014. T. 3. - S. 309–318.

18. Hu Y. A model layout region optimization for feeder buses of rail transit // Procedia-Social and Behavioral Sciences / Y. Hu, Q. Zhang, W. Wang. - 2012. - V. 43. - P. 773–780.

19. Kabashkin I. Modeling of Regional Transit Multimodal Transport Accessibility with Petri Net Simulation // Procedia Computer Science / I. Kabashkin. - 2015.– T. 77. - P. 151–157.

20. Kalaanidhi S. Estimation of Bus Transport Ridership Accounting Accessibility // Procedia-Social and Behavioral Sciences / S. Kalaanidhi, K. Gunasekaran. –2013. - Vol. 104. - P. 885–893.

21. Li T. A demand estimator based on a nested logit model // Transportation Science / T. Li. - 2016. - V. 51. - № 3. - P. 918–930.

22. Modeling monthly flows of globalair travel passengers:

An open-access data resource // Journal of Transport Geography / L. Mao et al. - 2015. - V. 48. - P. 52–60.

23. Menukhova T. Using of Regionalization Techniques to Select Optimal Routes Based on Criteria of Road Features // Transportation Research Procedia / T. Menukhova, A.Vyushkova. - 2017. - V. 20. - P. 436–442.

24. Moreno EG A first step to diagnostic of urban transport operations by means of GPS receiver // Procedia Computer Science / EG Moreno MG Romana, O. Martínez. - 2016. - V. 83. - P. 305–312.

25. Panasyuk MV Optimization of regional passenger bus traffic network // Procedia Economics and Finance / MV Panasyuk. EM Pudovik, ME Sabirova. - 2013. - V. 5. - P. 589–596.

26. Park M. Regional freight demand estimation using Korean commodity flow survey data // Transportation Research Procedia / M. Park, J. Hahn. - 2015. - V. 11. - P. 504–514.

27. Demand variations and evacuation route flexibility in short-notice bus-based evacuation planning // IATSS research / AN Qazi et al. - 2017. - V. 41. - № 4. - P. 147–152.

28. Analyzing inter-modal competition between high speed rail and conventional transport systems: A game theoretical approach // Procedia-Social and Behavioral Sciences / V. Raturi et al. - 2013. - V. 104. - P. 904–913.

29. Richter C. Modeling mode choice in passenger transport with integrated hierarchical information integration // Journal of Choice Modeling / C. Richter, S. Keuchel. - 2012. - V. 5. - № 1. - P. 1–21.

30. Rwakarehe EE Development of a Freight Demand Model for the Province of Alberta Using Public Sources of Data // Procedia-Social and Behavioral Sciences / EE Rwakarehe, M. Zhong, J. Christie. - 2014. - V. 138. - P. 695–705.

31. Schwieterman J. Intercity Buses: 2015 Was A Smooth Ride // New Geography / J. Schwieterman. - 2016

32. Spichkova M. Formal model for intelligent route planning // Procedia Computer Science / M. Spichkova. M. Simic, H. Schmidt. - 2015. - V. 60. - P. 1299–1308.

33. Sun DJ Timetable optimization for single bus line based on hybrid vehicle size model // Journal of Traffic and Transportation Engineering (English Edition) / DJ Sun, Y. Xu, ZR Peng. - 2015. - V. 2. - № 3. - P. 179–186.

34. Joint optimization of a rail transit route and bus routes in a transit corridor // Procedia-Social and Behavioral Sciences / Y. Sun et al. - 2013. - V. 96. - P. 1218–1226.

35. Terekhov I. A concept of forecasting origin – destination air passenger demand between globalcity pairs using future socio-economic scenarios // 53rd AIAA Aerospace Sciences Meeting / I. Terekhov, V. Gollnick. - 2015 -AU. 1640

36. Tuaycharoen N. Bangkok Bus Route Planning API // Procedia Computer Science / N. Tuaycharoen, A. Sakcharoen, W. Cha-aim. - 2016. - V. 86. - P. 441–444.

37.Vissat LL Finding optimal timetables for Edinburgh bus routes // Electronic Notes in Theoretical Computer Science / LL Vissat, A. Clark, S. Gilmore. - 2015. - V. 310. - P. 179–199.

38. Two-dimensionally constrained disaggregate trip generation, distribution and mode choice model: Theory and application for a Swiss national model // Transportation Research Part A: Policy and Practice / M. Vrtic et al. - 2007. - V. 41. - № 9. - P. 857–873.

39. Wu C. Airport attractiveness analysis through a gravity model: A case study of Chubu International Airport in Japan // Proceedings of the Eastern Asia Society for Transportation Studies The 9th International Conference of the Eastern Asia Society for Transportation Studies / C. Wu, J. Han , Y. Hayashi. - Eastern Asia Society for Transportation Studies, 2011. - P. 419–419.

40. Xiao-qiang L. The Passenger Demand Prediction for Airport Line of Rail Traffic // Metallurgical & Mining Industry / L. Xiao-qiang, W. Lei. - 2015. - № 9.

41. L. Youlong. Route Optimization Algorithm and Solution for Web Service Engineering // Systems Engineering Procedia / N. Guihua. - 5. - P. 427–436.

42. Zhang C. Bus dwell time estimation and prediction: A case study in shanghaichina // Procedia-Social and Behavioral Sciences /L. Youlong,

J. Teng. - 2013. - V. 96. - P. 1329–1340.

43. Modeling the effects of low-carbon emission constraints on mode and route choices in transportation networks // Procedia-Social and Behavioral Sciences / X. Zhang et al. - 2013. - V. 96. - P. 329–338.

44. Zhu W. Generating route choice sets with operation information on metro networks // Journal of Traffic and Transportation Engineering (English Edition) / W. Zhu, R. Xu. - 2016. - V. 3. - № 3. - P. 243–252.

45. Dolya KV 3D modeling of heterogeneous spatial information in GIS as a means of land resources management [Collection of reports] // Materials All-Ukrainian. scientific-practical conf., dedicated. 70th anniversary of the Department of Land Resources Management and Cadastre / KV Dolya, OE Dolya. - Kharkiv: 2016. - P. 167.

46. Economic-mathematical modeling influence of the environment at the development of passenger transport systems // Scientific herald of the Kherson State University. Ser .: Economic Sciences. / KV Dolya et al. - 2016. - № 16 (1). - P. 152–154.

47. K. Share. Geovirtual Urban Environments as Media for the Communication of Information Related to Managing Urban Land [Conference] // Proceedings of the scientific-practical conference dedicated to the International Day of Geoinformation Systems / K. Dolya, O. Dolya. - Kharkiv: [b.n.], 2016. - P. 57–59.

48. Improving efficiency of transportation service method for routs using similar vehicle's type [Книга] / A. Galkin, E. Kush, C. Doliaet al.- 2016

49. The fate of K. On the distribution of transport work in the system of urban passenger transport // Eastern European Journal of Advanced Technologies. K. Share. - 2011. - T. 5, № 3 (53). - P. 18–21. - Access mode: DOI: 10.15587 / 1729–4061.2011.1186.

50. . Influence of features of the transport network pattern on the haul cycle length between its nodes on the example of the transport network of Ukraine // Technology audit and production reserves / C. Dolya et al. - 2017. - Vol. 5. - № 2 (37). - P. 54–58.

51. Dolia K. Influence of the seasonal factor on the long-distance passenger correspondence // Technological Complexes - Kharkiv: OM Beketov National University of Urban Economy / K. Dolia. - 2017 - Vol. 1 (14). - P. 57–67.

52. Dolia K. Influence of the seasonal factor on the passenger correspondence [Article] // Visnyk of Zhytomyr State Technological University / K. Dolia. - 2017

53. Dolya C. Investigation of approaches to modeling of intercity passenger transportation system // Technology audit and production reserves / C. Dolya, A. Botsman, V. Kozhyna. - 2017 -Vol. 4. - № 2 (36). - P. 24–28.

54. Dolya C. Math modeling of influence environment at the development of passenger transport systems // International scientific-practical conference / C. Dolya, O. Dolya. - 2016. - P. 292.

55. Dolya C. Methods of Establishing and Implementing the Optimal Fares for Passenger Transport // American Journal of Traffic and Transportation Engineering / C. Dolya, O. Dolya. - 2016 - 4: Vol. 1. - P. 60–67.

56. Dolya KV MODELING OF DEVELOPMENT OF TRANSPORT SYSTEMS IN MODERN ENVIRONMENT // Young / KV Dolya. - 2016. - Vol. 40. - № 12.1.

57. DolyaC. Modeling of intercity passenger transportation system // Technology audit and production reserves /C. Dolya. - 2017. - № 2 (2). - P. 37–43.

58. Dolya C. Modeling of passenger transport correspondence between regional centers in Ukraine // Technology audit and production reserves / C. Dolya. - 2017. - Vol. 1. - № 2 (33). - P. 44–48.

59. Modeling of polygons of maximum passenger route transport accessibility by the example of the transport system of Ukraine // Technology audit and production reserves / K. Dolia et al. - 2017. - Vol. 6. - № 2 (38). - P. 28–33.

60. Доля К. Б. State regulation and legal support for entrepreneurial activities of business entities, which provided services for the carriage of passengers on public bus routes in Ukraine / К. Б. Доля, О. Є. Доля.

61. Dolya C. The Issue of Probability of Traffic Road Accident on the Elements of the Transport Network // American Journal of Social Science

Research / C. Dolya, N. Gyulyev. - 2017 - 5: Vol. 3. - P. 17–24.

62. Relationships between the characteristics of the road network and the density of urban development [Conference] / ed. KV Dolya, OE Dolya // European standards of assessment, land management and cadastre: problems of implementation and ways of their implementation in Ukraine: materials of the international scientific-practical conference. - Kharkiv: [b.n.], 2016.

63. Definition of passenger correspondence in transport systems [Article] / ed. KV Dolya // Modern technologies and methods of calculations in construction. - 2017 - RVV Lutsk NTU. - Vol. 8. - 65–71.

64. Influence of features of drawing of a transport network on length of a ride between its knots on an example of a transport network of Ukraine [Article] / ed. Constantine Dolya, Sergey Lyfenko, Sergey Nesterenko, Constantin Vyatkin // Technological audit and production reserves .. - 2017 - pp. 54–58.

65. Influence of seasonal factors on long-distance passenger correspondence [Article] / ed. KV Dolya // Bulletin of Zhytomyr State Technological University. Series: Technical Sciences. - Zhytomyr: [b.n.], 2017 - 2 (80) Vol. 1. - pp. 144–152.

66. Influence factor seasonality on passenger correspondence [Conference] / ed. KV Dolia // Sustainable urban development (urban aspect). - Kharkiv: [b.n.], 2017. - pp. 119–121.

67. Geoinformation systems in transport [Article] / ed. KV Dolya, OE Dolya // Manual for practical and independent classes. - Kharkiv: KhNUGH them. OM Beketova, 2017 - pp. 1-230.

68. Geoinformation systems in transport [Book] / ed. KV Dolya, OE Dolya. - Kharkiv: KhNUMG them. OM Beketova, 2018. - pp. 1-230.

69. GIS and railway transport [Collection of reports] / ed. KV Dolya, AO Cherna, AS Kolotova // Proceedings of the international scientific-practical conference dedicated to the fiftieth anniversary of the Department of Land Administration and Geoinformation Systems. - Kharkiv:

[b.n.], 2016. - P. 167.

70. GIS and systems of automated design of roads on the example of indorcad / renew [Conference] / ed. KV Dolya, KA Lototska, EO Elizarova // Proceedings of the international scientific-practical conference dedicated to the fiftieth anniversary of the Department of Land Administration and Geoinformation Systems. - Kharkiv: [b.n.], 2016. - p. 167.

71. Dispatching in GIS as a means of solving the territorial needs of the community [Conference] / ed. KV Dolya, A. Yu. Tereshchenko, DA Garibyan // Proceedings of the international scientific-practical conference dedicated to the fiftieth anniversary of the Department of Land Administration and Geoinformation Systems. - Kharkiv: [b.n.], 2016. - p. 167.

72. Differentiated assessment of urban passenger transport work [Article] / ed. KV Dolya // Bulletin of the Dnipropetrovsk National University of Railway Transport named after Academician V. Lazaryan. - Dnipropetrovsk: [b.n.], 2008 - 25. - pp. 146–148.

73. Application of geoinformation systems in the organization of cargo transportation [Conference] / ed. KV Dolya, NS Makivets // Proceedings of the All-Ukrainian scientific-practical conference "Modern aspects of real estate market formation: domestic and international experience". -

Kharkiv: [b. n.], 2017. - p. 79.

74. Application of modern technologies in municipal management [Conference] / ed. KV Dolia // Modern aspects of real estate market formation: domestic and international experience. - Kharkiv: [b.n.], 2017. - p. 80.

75. On the issue of the efficiency of transport services for several routes by the same type of vehicles [Article] / ed. AS Galkin, KV Dolya, AO Oliynikova, MO Zhigiliy // Communal economy of cities. - Kharkiv: [b.n.], 2017 - 135. - pp. 147–153.

76. Dolya K. Network modeling and analysis of transport processes in GIS [Book] / ed. Constantine Dolya. - Kharkiv: Science and Technology, 2018.

77. Modeling of transport correspondence [Article] / ed. Konstantin Dolya, Igor Bugayov // Young Scientist. - Kharkiv: [b.n.], 2017 - 3. - pp. 725–728.

78. Peculiarities of urban passenger transport systems management [Book] / ed. KE Vakulenko, KV Fate. - Kharkiv: NTMT, 2013. - p. 171.

79. Improving the organization of road traffic and transportation of passengers and goods [Article] / ed. The share of Constantine // Belarusian National. tech. University - 2012 - p. 465.

80. Modern methods, innovations and experience of practical application in the field of technical sciences [Collection of reports] / ed. K. V. Share. - Kharkiv: [b.n.], 2017.

81. Management of urban passenger transport: textbook. manual [Article] / ed. KV Dolya, KE Vakulenko // KhNUMG them. OM Beketov. - 2014 - p. 260.

82. Formalization of the gravitational model for calculating the parameters of long-distance passenger correspondence [Article] / ed. K. V Dolya // Science and Technology. - [b.m.]: Belarusian National Technical University, 2017 - 5 p.

83. On the application of gravitational modeling in network analysis [Article] / ed. KV Dolya, Yu. Yu. Boyko // Communal economy of cities. - Kharkiv: [b.n.], 2017 p. - 139. - pp. 98–103.

84. On the possibility of practical implementation of means of development of route passenger transport systems [Article] / ed. Konstantin Dolya, Olena Dolya // Young Scientist. - Kharkiv: [b.n.], 2017 - 1. - pp. 41–44.

85. On the accounting of traffic flow and decision-making on the organization of traffic by GIS [Conference] / ed. KV Dolya, KO Salo, OV Soroka // Proceedings of the international scientific-practical conference dedicated to the fiftieth anniversary of the Department of Land Administration and Geoinformation Systems. - 2016. - p. 167.

86. On the indicators of urban passenger traffic [Article] / ed. KV Dolya // Bulletin of the Donetsk Academy of Motor Transport. - 2011 - 3. - pp. 20–25.